companion

THE
Seaman's Companion,

BEING

A Plain Guide to the Underſtanding

OF

ARITHMETICK, GEOMETRY, TRIGONOMETRY, NAVIGATION, and ASTRONOMY.

Applied Chiefly to

NAVIGATION:

AND

Furniſhed with a Table of *Meridional* Parts, to every third Minute: With excellent and eaſie ways of keeping a Reckoning at Sea, never in Print before.

ALSO,

A Catalogue of the Longitude and Latitude of the principal Places in the World: With other uſeful things.

The Third Edition corrected and amended.

By MATTHEW NORWOOD, *Mariner.*

LONDON,

d by *Anne Godbid*, and *John Playford*, for *William Fiſher*,
at the *Poſtern-Gate* near *Tower-Hill*; *Robert Boulter*, at the *Turks-Head*, and *Ralph Smith*, at the *Bible* in *Cornhill*; *Thomas Paſſinger*,
at the *Three Bibles* on *London-Bridge*; and *Richard Northcot*,
next St. *Peter's-Alley* in *Cornhill*, and at the *Anchor* and *Mariner*,
on *Fiſhſtreet-Hill*.

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TO THE

READER.

THE famous and ever to be admired Art of Navigation, having been ſo learnedly handled and written of, not only in all other Languages, but alſo in our Mother-Tongue, by ſo many learned and able men, both of former and of our preſent Age, that it may ſeem impoſſible to write any thing more thereof that hath not already been done by others; yet in my experience which I have ſeen, being at Sea in ſeveral Veſſels, where divers young Mariners have been: I have heard this general Complaint among them, that though the things that are chieſly uſeful for them in their Art may be found in ſeveral Books here and there diſperſed; yet they could wiſh that there were ſuch a Book contrived, that might be ſoley uſeful for them entire by it ſelf, which then would be more convenient for them, and might be purchaſed at a more reaſonable rate than otherwiſe they could be, by buying of ſo many ſorts of Books, which they muſt be conſtrained to do, if ever they intend to be able Proficients in that moſt noble Profeſſion of Navigation, at which they chiefly aimed.

This Complaint of theirs, was one chief Motive which induced me to collect and compoſe the ſubſequent Treatiſe, which I have endeavoured to handle in ſuch a methodical manner, as it ought to be read and practiſed by the young Seaman. For

Firſt, There is a Treatiſe of ARITHMETICK, containing all the Rules thereof, which are neceſſary for the Seaman to know and practiſe, all or moſt of the Queſtions thereof being made applicable in one kind or other to Nautical Affairs.

Secondly, There is a Treatiſe of GEOMETRY, containing the firſt Grounds and Principles thereof, with the making and dividing of the

Mariners Scale and Compaſs, with the projecting of the Sphere in Plano, and the reſolving of many Queſtions in Aſtronomy, which are uſeful in Navigation thereby.

Thirdly, you have a Treatiſe of the practick part of NAVIGATION, wherein is ſhewed, after a new experienced way uſed by the Author, how to keep a Reckoning at Sea: the making and uſe of the Plain Sea-Chart: the Doctrine of plain Triangles made applicable to ſuch Queſtions in Navigation as concern Courſe, Diſtance, Rumb, Difference of Longitude, and Departure: likewiſe, a Table of Meridional parts to every third Minute, and the application and uſe thereof exemplified in Queſtions of Sailing by *Mercator's* Chart: with Tables of Longitude and Latitude of Places, of right Aſcenſion, and Seaſons of certain Fixed Stars, with Rules to keep a Reckoning, and to find the Latitude by the Meridian Altitude of the Sun or Stars.

Fourthly, There is a ſhort Treatiſe of ASTRONOMY, wherein you have the Doctrine of Spherical Triangles applied to Queſtions in Aſtronomy and Navigation.

This is the brief Sum and Subſtance of the following Treatiſe, which I commend to the

Practice of all young Sea-men, deſiring their kind acceptance of theſe my firſt Labours, which if I ſhall find to be kindly entertained by them, it will encourage me to lanch farther into the more nice and critical part of this moſt noble Science. In the mean time I commend this to them, wiſhing good ſucceſs in all their honeſt and laudable undertakings, and in the interim bid them Farewel.

MATTHEW NORWOOD.

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OF ARITHMETICK.

THE TABLE.

7000000000000	*Millions of millions.*
800000000000	*Hundred thouſand millions.*
90000000000	*Ten thouſand millions.*
6000000000	*Thouſand millions.*
500000000	*Hundred millions.*
30000000	*Ten millions.*
2000000	*Millions.*
800000	*Hundred thouſands.*
40000	*Ten thouſands.*
5000	*Thouſands.*
700	*Hundreds.*
10	*Tens.*
1	*Units.*

The Uſe of the Table to number.

THis Table ſignifies thus much, That if there be one Figure alone, it is but ſo many units as there is in its name, as 7 is ſeven ones or units. If there be two Figures, the firſt Figure towards the left hand is as many tens as there is units in its name, and the other Figure is units: As if it were 10, that is ten units: if it were 23, the firſt Figure is two tens, that is twenty units: and the next Figure is 3, that is three units. The next place is hundreds, and conſiſts of three Figures, as 700 is ſeven hundred: 723 is ſeven hundred twenty three. And thus you may count any Number by obſerving the place of any Figure, and in their places giving them their names as you count: As ſuppoſe I have a Number, namely 7864319, if you tell from 9 backwards to 7, you will find 7 in the place of millions, then begin and ſay ſeven millions: then if you count again, you will find 8 in the place of hundred thouſands, 6 in the place of ten thouſands, and 4 in the place of thouſands, then to give them their proper Number, you will read thus: Seven millions for 7, eight hundred thouſand for 8, ſixty thouſand for 6, four thouſand for 4, that is, Seven millions eight hundred ſixty four thouſand; then for 3 three hundred, for 1 ten, and for 9 nine units, that is then altogether 7 millions 8 hundred 64 thouſand 3 hundred and ninteen, which is the quantity of units that is in the given Number 7864319. And thus much for Numeration.

Addition.

ADdition teacheth how to bring ſeveral Sums into one total, and is done as in the Example, thus: Suppoſe there be ſeveral Perſons indebted to me, and they owe as followeth:

I demand what the debt is? Add the numbers together thus, begin at the right hand, and for every ten carry one to the next row, adding them up in their ſeveral rows, til you come to the laſt row on the left hand, and as many tens as is in that after it is added up, ſo many ſet down by it in the next place on the left hand.

Example.

A *oweth*	7272
B *oweth*	2732
C *oweth*	3399
D *oweth*	3999
Total is, or debt	17402

Example.

In the firſt row towards the right hand, ſay 9 and 9 is 18, and 2 is twenty, and 2 is twenty two, which ſhould be expreſſed thus 22: but becauſe the next place is the place of tens, you ſet down 2 units, and carry the other two (which is two tens) and add them to the next row of tens, by ſaying 2 that I carried and 9 is eleven, and 9 is twenty, and ſo forwards, ſtill doing ſo till you come to the laſt row, and as many tens as there is in that, ſo many ny ſet down to the left hand ; as here it came but to 17, that is but one ten beſides the 7 : if they come to even tens (as here one row came to thirty) ſet down 0, and carry the tens to the next place, except it be in the laſt row to the left hand, and then ſet down 0, and your number of tens to the left hand of it.

The Characters uſed in Arithmetick.

For pounds	*l.*	For degrees	*deg.*	Minutes of time	′
For ſhillings	*s.*	For minutes	′	For hundreds	*C.*
For pence	*d.*	For ſeconds	″	For quarters	*qu.*
For farthings	*q.*	For hours	*ho.*	For ounces	*oun.*

Addition of Degrees and Minutes.

NOte that ſixty Minutes is one Degree, three Miles is one League, ſixty Seconds is one Mile or Minute, ſixty Minutes of time is one Hour in time : fifteen Minutes of a Degree is one Minute in time, twelve Hours is an artificial Day, twenty four Hours is a natural Day, fifteen Degrees is an Hour in time, four Minutes of time is one Degree, three hundred and ſixty Degrees is the Circumference of a Circle, one hundred and eighty Degrees is half a Circle, or a Semicircle ; ninety Degrees is a Quadrant, or a quarter of a Circle, and eleven Degrees fifteen Minutes is one point of the Compaſs, two and thirty times eleven Degrees fifteen Minutes is the Circumference of a Circle ; ſo that there is two and thirty points of the Compaſs in every Circle : one point of the Compaſs is three quarters of an Hour in time, or 45 Minutes.

Admit I had kept an account of a Ships Difference of Longitude in Degrees and Minutes, that had been out eight days, and had made Difference of Longitude each day, as followeth :

The firſt day	2 *deg.*	20′	The fifth day	2 *deg.*	39′
The ſecond day	2 *deg.*	45	The ſixth day	1 *deg.*	29
The third day	1 *deg.*	30	The ſeventh day	2 *deg.*	19
The fourth day	1 *deg.*	11	The eighth day	2 *deg.*	10

I deſire to know (if it be all one way) what number of degrees and minutes it is in one ſum.

Begin as you did in Addition, and ſay 9 and 9 is 18, and 9 is 27, and 1 is 28, and 5 is 33, ſet down 3 and carry 3: then ſay 3 that I carried and 1 is 4, and 1 is 5, and 2 is 7, and 3 is 10, and 1 is a 11, and 3 is 14, and 4 is 18, and 2 is 20: caſt out all the ſixes from 20, and there remains 2, ſet it down, and as many ſixes as you caſt away, ſo many units carry to the place of Degrees (which was three ſixes) and ſay 3 that I carried and 2 is 5 and ſo forwards in that as in any other Sum in Addition: it being thus added, I find that it comes to 16 *d.* 23 *m.* the whole.

Now you may ask a reaſon why I caſt away the ſixes, the reaſon is becauſe 6 tens make a degree: now with the three tens that I carried, and the tens that where in the row added up laſt, there were 20 tens, that muſt be 3 degrees and 2 tens over: the 3 degrees I carry to the place of degrees, and the two tens I ſet down in the place of tens: and thus in any other Sum.

2 deg.	20'
2 deg.	45
1 deg.	30
1 deg.	11
2 deg.	39
1 deg.	29
2 deg.	19
2 deg.	10
16 deg.	23

Addition of Hours and Minutes.

ADmit I have theſe ſeveral numbers of hours and minutes to caſt up in one ſum, namely, then becauſe 60 minutes is one hour, I do juſt as I did before: be ſure in the place of minutes ſet never above 60, for if you do, it is more than a degree.

ho.	min.
41	07
22	11
12	29
18	32
15	15
109	34

The ſame is to be done in Addition of Money, only remembring in the place of pence to go no farther than 12, becauſe twelve pence make a ſhilling, as you do here to 60, becauſe 60' makes a degree, and in ſhillings no farther than twenty, becauſe twenty ſhillings make a pound. And thus in any thing elſe (provided that you know how many of the one makes one of the other) but for ſuch things they are not ſo neceſſary to the thing we purpoſe to handle, and therefore I refer you to Mr. *Hodder*'s Book, it being of ſmall price, and much matter, and likewiſe very plain.

Subtraction.

SUbtraction is the taking a leſſer number from a greater, and to ſee what remains: As ſuppoſe a man was bound from *Cales* to *Dover*, which is 21 miles: now if he have ſailed 11 miles of the way, I demand what he hath yet to ſail? Take 11 from 21, and the remainder is 10, ſo I conclude he hath 10 miles ſtill to ſail before he come to *Dover:* but in greater numbers they are ordinarily ſet ſo that you are forced to borrow, ſo that they are ſomething harder.

Suppoſe the diſtance between two places be —— 1799 *miles.*
Now I have ſailed of theſe miles ———— 1227
I demand what number of miles I have ſtill to ſail. } *Still to ſail* —— 0572

Set the greateſt number uppermoſt, and the leaſt under it, and draw a line between them, and a line under them both, and ſay, 7 from 9 and the remainder is 2, ſet down 2: then 2 from 9, there remains 7 ſet it down: then 2 from 7, and the remainder is 5: whatſoever number is underneath ſo much is ſtill to ſail, as here 572 miles.

But now I'll give you an Example wherein the figures in the leſſer Sum, are ſome of them bigger than in the greater, from which they muſt be taken: now in ſuch a caſe borrow ten, and add to the upper figure.

Example.

A oweth to *B* 7822 pound of Tobacco, now he hath paid 4998 *l.* of it: I demand what is ſtill due.

Whole Debt — 7822 *l*
Received — 4998
Still due — 2824

Set down your ſums as in the former directions, and ſay 8 from 2 I cannot, but 8 from 12, and the remainder is 4: ſet it down, 1 that I borrowed and 9 is 10, from 2 I cannot, but 10, from 12, and the remainder is 2, ſet down 2 and carry 1, then 9 and 1 that I carried is 10, from 8 I cannot, but 10 from 18, and the remainder is 8 ſet down 8 and carry 1: then 1 that I carried and 4 is 5: 5 from 7 and the remainder is 2, ſet it down, and thus you may do any ſum of one denomination.

Subtraction of Degrees and Minutes.

THis being of ſeveral Denominations, obſerve as before in Addition (of degrees and minutes) how many of the one makes one of the other: and if the under figures be bigger than the uppermoſt (in the place of minutes) borrow from 60 the denominator of a degree, and ſubtract from it, and that remainder add to the upper figure, and ſet it down: but in the place of degrees, if the under number be bigger, do as you did before.

I have made in my Reckoning ——— } *Difference of Latitude North* 32 deg. 48′
Difference of Latitude South 29 deg. 59

I demand what way I have differ'd my Lat. moſt, and how much? } *I have differed my Latitude* 02 deg. 49 *and it is Northerly, becauſe my Northing is more than my Southing.*

Say 9 from 8 I cannot, but 9 from 18 there remains 9, ſet it down; 5 and 1 that I borrowed is 6, 6 from 4 I cannot, but 6 from 6, and the remainder is 0, that 0 and 4 is 4: ſet it down, then 1 that I borrowed and 9 is 10, from 21 cannot, but 10 from 12, and there remains 2, ſet it down: 1 that I carried and 2 is 3, 3 from 3 and there remains 0, ſo that —— 32 *deg.* 48 *min.*
is ——— 02 *deg.* 49
more than 29 *deg.* 59

The ſame may be done in Subtraction of pounds, ſhillings, and pence, obſerving but how many of the one goes to make one of the other: be ſure in ſetting down a ſum, you do not ſet more minutes in the place of minutes than 60, or pençe in the place of pence than 12, or ſo for any thing elſe ſet no more than goeth to make one in the next denomination.

Subtraction of Time.

LEt the greateſt number of time be ——— 272 *hor.* 22 *min.*
Let the leſſer number of time be ——— 199 *hor.* 49 *min.*

The Remainder of time is ——— 072 *hor.* 33 *min.*

You may try this over: it is done as the former, and needs no demonſtration (as I ſaid before) if you obſerve in any caſe how many of one makes one of the other, it is but borrowing from that number, as we have done here.

THE

The TABLE.

2 times	2	is	4
	3		6
	4		8
	5		10
	6		12
	7		14
	8		16
	9		18

3 times	3	is	9
	4		12
	5		15
	6		18
	7		21
	8		24
	9		27

4 times	4	is	16
	5		20
	6		24
	7		28
	8		32
	9		36

5 times	5	is	25
	6		30
	7		35
	8		40
	9		45

6 times	6	is	36
	7		42
	8		48
	9		54

7 times	7	is	49
	8		56
	9		63

8 times	8	is	64
	9		72

9 times	9	is	81

This Table is ſo familiar to any one, that I need to ſay but little concerning it; when you read it, read thus: 2 times 2 is 4, 2 times 3 is 6, and ſo along to 2 times 9 which is 18, then go to the next, and ſay 3 times 3 is 9, then 3 times 4 is 12, and ſo forwards. Now I wiſh the Learner to have theſe Tables perfect by heart, before he proceed further.

Multiplication.

IT doth Addition many times, for when you have many Additions it makes one work of it, and alſo of two given Numbers it increaſeth the greater as often as there is units in the leſſer, or the leſſer as often as there is units in the greater. Now in multiplying there are three things conſiderable.

Firſt, The Multiplicand, or Number that you would multiply.

Secondly, The Multiplier, or Number you multiply by.

Thirdly, The Product or Sum produced.

Queſt. 1. *I demand how many Feet there are in* 320 *Yards, every Yard being three Feet?*

If you ſet down 320 yards one under the other three times, and add them, you will have the ſum of 320 yards in feet: but that is a tedious way, for then you muſt ſet down your 320 yards an hundred times one under the other, if there were one hundred times ſo much (of any thing) in it: but now Multiplication doth it at once; becauſe there is 3 foot in a yard, therefore there muſt be three times 320 foot in 320 yards.

Example. I ſet down 320 and 3 under the firſt figure on the right hand, and ſay 3 times 0 is 0, ſet down 0, then 3 times 2 is 6, ſet down 6: then 3 times 3 is 9, ſet down 9, ſo the Product is 960 feet, which anſwers your demand. *Note*, that when your Multiplication cometh to more than 9, as many tens as are in it, ſo many you carry to the next place, (as you did in Addition) and ſet down the reſt, as you ſhall in this Example following.

Multiplicand	320
Multiplier	3
Product	960

Queſt. 2 *I demand how many Minutes is in* 360 *Degrees?*

Note that 60 minutes is one degree: it is leſs work always to make your greateſt Number your Multiplicand, and then it ſtands as in the Margin: then ſay 0 nothing is 0, ſet down 0; then 0 ſix is 0, ſet it down; then 0 three is 0, ſet it down: then go to 6, and ſay 6 times 0 is 0, ſet it down, one figure to the left hand under the former; then ſay 6 times 6 is 36, ſet down 6 and carry 3; then ſay 6 times 3 is 18, and 3 that I carried is 21, ſet down 1 and carry 2; now becauſe there is no more figures, ſet down the two (as I have ſhewed in Addition) and thus 360 degrees is 21600 minutes, if both the Products be added together. Then to prove your work, add up your Multiplicand, and caſt away the nines from it, and ſet the remainder down over the Croſs; then caſt away the nines of the Multiplier if it comes to 9, but if not, ſet it down under the Croſs; then multiplie 6 by 0, and it makes 0, ſet down that on the right ſide of the Croſs; then caſt up your Product, and caſt away the nines from it, and if it comes to the ſame that the Multiplicand and Multiplier did, (the nines being caſt away) then the ſum is done right, and ſtands as you ſee in the Margin. I ſhall here following

$$\begin{array}{r} 360 \\ 60 \\ \hline 000 \\ 2160 \\ \hline 21600 \end{array}$$

$$\overset{0}{\text{X}}$$

$$\overset{0}{\underset{6}{\text{X}}}$$

$$\overset{0}{\underset{6}{\text{X}}}\,0$$

$$0\,\overset{0}{\underset{6}{\text{X}}}\,0$$

ſhew two Examples, and ſet down two more for your practice: if you do not underſtand what is ſaid, examine theſe Examples which are wrought, and they will ſatiſfie you.

Queſt. 3. *How many units is* 612345 *times* 62453125 *units?*
Queſt. 4. *How much is* 123456 *times* 45321672?

Let theſe be the two Queſtions which here following are wrought one after the other.

62453125
612345

312265625
249812500
187349375
124906250
62453125
374718750

1
3 X 3
3

The Product of the firſt Queſtion 38242858828125

45321672
1234567

317251704
271930032
226608360
181286688
135965016
90643344
45321672

3
3 X 3
1

The Product of the ſecond Queſtion 55952640636024

Queſt. 5. *How many units is in* 3438239 *times* 5289231423?
Anſw. 18185641758584097.
Queſt. 6. *How many units is in* 289764532172 *times* 343217812?
Anſw. 99452348727277447664.

Diviſion.

Diviſion is that by which one may know (at one operation) any part of a whole Number, provided that the part be not under an unit: by part I mean thus, the third of a number, or the fourth of a number, or the twentieth part of a number, or the like.

In Diviſion there are four things conſiderable: Firſt, the Dividend; Secondly, the Diviſor; Thirdly, the Quotient; And fourthly, the Remainder after the Diviſion.

The Dividend is the number which you deſire to have divided, or to have a part known.

The Diviſor is that which you divide it by, or the name of the part which you would have known.

The Quotient is the number of units that is contained in the part required.

And the Remainder of the Diviſion is that part under an unit, which is wanting to the true portion which is left in the Quotient.

Your Sum when you ſet it, ſtands thus: } 3478 (
224

Queſt. 1. *A man promiſed to do a Piece of work for me in a Quarter of a Year: Now if there be 365 Days in a Year, I deſire to know how many Days is in this Quarter?*

The fourth part of 365 days muſt needs be the number of days which this man will be doing the Piece of Work, therefore divide 365 days by 4, and the Quotient ſhall be the whole days, and the remainder of the Diviſion ſhall be the parts of a day above the whole days. 91 days, and one fourth of a day is a quarter of a year, or the quantity of time he will be doing this Work. We expreſs a Fraction thus: one fourth $\frac{1}{4}$, two fifths $\frac{2}{5}$, or ſo for any Fraction.

$\cancel{0}$ (1
Example $\cancel{3}\cancel{6}\cancel{5}$ (91
$\cancel{4}\cancel{4}$

But you will ask how this is done? Which is thus: Firſt, ſet down your Dividend 365; then to the left hand ſet down

365 (
4

the Diviſor under your Dividend. but you will ask why I did not ſet it under the 3? And the reaſon is, becauſe 4 is more than 3, ſo that I could have had nothing from 3 till I had removed it where it is: if 3 had been a number that I could have took my Diviſor from, I would have ſet the 4 under the 3.

Your Sum being ſet, ſay how many times 4 can you have in 36? Nine times. Set down 9 in the Quotient, and multiply 4 by 9, ſaying 9 times 4 is 36, from 36 and the remainder is 0: cancel 4 and 36 as you go (by a daſh with your pen) and your work ſtands thus:

0
365(9
4

Then ſet your 4 under the 5, and ſay how many times 4 can you have from 5? Once. Set down 1 in the Quotient, and multiply it by 4, ſaying, once 4 is 4, from 5, and the remainder is 1: ſet 1 over the 5, cancelling your 4 and 5 by a daſh with your pen (as you ſpeak:) now becauſe there is no more figures, your ſum is done, and ſtands thus:

The 1 which remains is $\frac{1}{4}$ of a unit (becauſe the Dividend is units) for whatſoever the Dividend is, the Quotient and the Remainder ſhall be a part of it: it hath its Denomination or Name from the Diviſor 4.

0(1
365(91
44

Queſt. 2. *A man had an Eſtate of* 78998 l. *now he oweth to* 23 *ſeveral men* 27821 l. *apiece. I demand what each man ſhall have of the Eſtate, ſo that none of them may be wronged?*

You will conclude becauſe they were owed alike, they ſhould have alike of that which was left, therefore divide the Eſtate by 23, and the Quotient with the Remainder will be each mans due.

Each will have 3434 *l.* $\frac{16}{23}$ of a pound for his Debt.

(1
112
1970(6
78998 (3434
23333
222

5
5 X 5
5

This is Diviſion of two figures when the Diviſor is two figures, and it is ſomething harder than the other Example: The working of it is thus, firſt ſet your Sum in order thus: Then I ſay, how many times 2 can you have from 7? Three times: 3 times 2 is 6, from 7 and there remains 1 (ſet 3 in the Quotient) and ſay again 3 times 3 is 9, from 18, and there remains 9, then your Sum ſtands thus:

$$\begin{array}{cccccl} 7 & 8 & 9 & 9 & 8 & (\\ 2 & 3 & & & & \end{array}$$

$$\begin{array}{cccccl} \cancel{1} & 9 & & & & \\ \cancel{7} & 8 & 9 & 9 & 8 & (3 \\ \cancel{2} & \cancel{3} & & & & \end{array}$$

You might have ſaid 3 times 3 is 9, from 8 I cannot, but 9 from 18, and the Remainder is 9, and 1 (for your borrowed one ten) from 1, and there remains 0, which is moſt eaſie for memory.

Then ſet your Diviſor on place further towards the right hand in this form:

$$\begin{array}{cccccl} \cancel{1} & 9 & & & & \\ \cancel{7} & 8 & 9 & 9 & 8 & (3 \\ \cancel{2} & \cancel{3} & 3 & & & \\ & 2 & & & & \end{array}$$

How many times 2 can you have from 9? Four times: then 4 times 2 is 8, from 9, and there remains 1, and 4 times 3 is 12, from 19 and the Remainder is 7: and 1 (for the ten) from 1, and the Remainder is 0; and then your Sum ſtands thus:

$$\begin{array}{cccccl} & \cancel{1} & & & & \\ \cancel{1} & \cancel{9} & 7 & & & \\ \cancel{7} & 8 & \cancel{9} & 9 & 8 & (34 \\ \cancel{2} & \cancel{3} & \cancel{3} & & & \\ & \cancel{2} & & & & \end{array}$$

Then remove your Diviſor to the next place, and ſee how many times 2 you can have out of 7, which is 3 times: 3 times 2 is 6, from 7 and the remainder is 1: and 3 times 3 is 9, from 9 and the remainder is 0; and your Sum ſtands thus:

$$\begin{array}{cccccl} & \cancel{1} & 1 & & & \\ \cancel{1} & \cancel{9} & 7 & 0 & & \\ \cancel{7} & 8 & \cancel{9} & \cancel{9} & 8 & (343 \\ \cancel{2} & \cancel{3} & \cancel{3} & \cancel{3} & & \\ & \cancel{2} & \cancel{2} & & & \end{array}$$

Then remove your Diviſor to the next place, and ſee how many times 2 you can have from 10? which is 5 times: now 5 times 2 is 10, from 10 and there remains 0, and 5 times 3 is 15, from 8 I cannot (you ſee 8 is all that is left, ſo that you have nothing to borrow from) therefore you could not take 5 times 23 from 108, try for 4 times, 4 times 2 is 8, from 10, and the remainder is 2, and 4 times 3 is 12, from 28 I can, you ſee you may take 4: ſet 4 in the Quotient, and ſay 4 times 2 is 8, from 0 I cannot, but 8 from 10, and the remainder is 2, and 1 that I borrowed from 1, and the remainder is 0, (cancel as you ſpeak) then 4 times 3 is 12: now 12 from 28, and the remainder is 16; but it is better to uſe your ſelf to this method, namely, to take your units from the place of units, and your tens from the place of tens, as here 2 is in the place of units, and 8 above, therefore ſay 2 from 8, and there remains 6, and 1 (for the ten) from 2 and the remainder is 1: Now if this had fallen out ſo that the upper number had been 21, and the other 12, you know that 12 will be taken out of 21, but 2 would not be taken out of 1; now in ſuch a caſe borrow one 10, and ſay as in Subtraction, 2 from 1 I cannot, but 2 from 11 and the remainder is 9, one 10 that I borrowed and 1 is 2, from 2 and there remains 0, and thus it is done at once: The reaſon why it is done this way is, becauſe the Sum you are to take from may be big, ſo that a man cannot tell readily what the remainder will be without Subtraction; for this differs nothing from Subtraction, as it is ſhewed before, but only that you carry one number in your head, whereas there both the numbers are before you.

The hardeſt Sum in Diviſion hath but theſe Difficulties in them:

Firſt, Be ſure take no more to ſet in the Quotient, than your Diviſor (multiplied by it) will come under the Number you are to take it from, or equal to it.

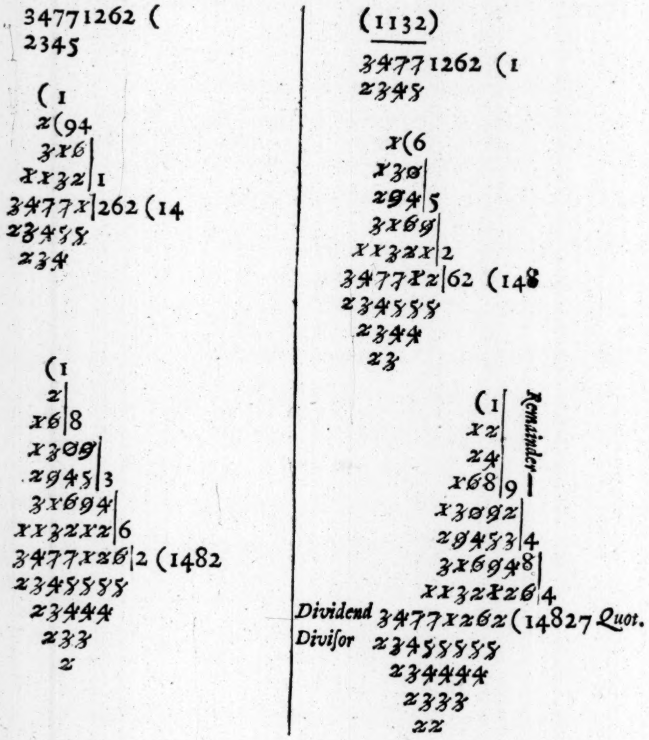
Secondly, Be ſure you take the one as many times as you can from the other.

Thirdly, Be careful in takeing one number from another, to uſe this way of Subtraction.

This Sum is done, and ſtands thus:
And it ſignifies that the 23. part of 78998 is 3434 units and $\frac{16}{23}$ of a unit.

$$\begin{array}{ccccccl}
 & & & & & (1 & \\
 & \cancel{1} & \cancel{1} & \cancel{2} & \vert & & \\
\cancel{1} & \cancel{9} & \cancel{7} & \cancel{0} & \vert & 6 & \\
\cancel{7} & 8 & \cancel{9} & \cancel{9} & & 8 & (3434 \\
\cancel{2} & \cancel{3} & \cancel{3} & \cancel{3} & & \cancel{3} & \\
 & \cancel{2} & \cancel{2} & \cancel{2} & & &
\end{array}$$

Here following is a Sum of four figures done, and the way to prove any Sum.



This Sum is ſet down in its ſeveral Operations. From what hath been ſaid already, I ſuppoſe you may be able to examine it; the like is to be underſtood of any Sum elſe in Diviſion, therefore I ſhall ſay no more, only ſhew how to prove them when they are thus wrought.

The beſt way to prove Diviſion is by Multiplication, for if you multiply your Quotient by the Diviſor, and add in the Remainder, that product will be equal to the Dividend, if the Sum be right, and it ſtands to reaſon it ſhould be ſo, for if the Quotient with the remainder be in this Sum the 2345th. part of the Dividend, then 'tis evident that 2345 times that Quotient muſt be the ſame that the Dividend is (with the remainder which is added in.)

Example.

Here you ſee the Example of it, and the Product the ſame that the Dividend of the Sum divided was, and this I ſay is the beſt way for young Practitioners to prove Diviſion, becauſe this makes them perfect in Multiplication.

Quotient 14827
Diviſor 2345
74135
59308 | 7
44481 | 4
26654 | 9
| 1 *Remainder*
Divid. 34771262

There is a ſhorter way to prove any Sum in Diviſion, and that is this: Caſt up your Quotient, and caſt away all the nines from it, (as you do in Multiplication) and what remains ſet down upon one ſide of a Croſs thus:

X 4

Then caſt away your nines from your Diviſor in like manner, and there remains 5, ſet it down on the other ſide againſt 4 thus:

5 X 4

Multiply them one by the other, and they produce 20, caſt away all the nines from 20, and the remainder is 2, keep this 2 in mind, and caſt up the remainder of the Diviſion, and caſt all the nines from it: which if it be done in this Sum, afterwards there will remain 3, which add to the 2 that was in your mind, and it makes 5, which ſet down thus:

5
5 X 4

Then caſt away all the nines from your Dividend, and the remainder will anſwer to the laſt number you ſet down in the Croſs, if the Sum be right, which here it is.

5
5 X 4
5

Reduction.

REduction ſheweth how to bring groſs or great Denominations into ſmall, or ſmall into great.

Queſt. 1. *Suppoſe a Man had been at Sea twenty five Years, and for every Minute of that time he was to have on Farthing, I demand how many farthings is due to him ?*

Here I ſee how many minutes is in that quantity of time, and ſo many minutes ſo many farthings there is due, which is, 13140000 farthings. Now to find this, I firſt multiply the years by the days contained in one year, which is 365, and that produceth 9125 days, the number of days in that number of years : this multiplied by 24 gives for its Product 219000 the number of hours in the whole time, becauſe 24 hours is a day. That Product multiplied by 60, is the number of minutes in the whole time (becauſe every hour is 60 minutes) which is the laſt Product, or the thing required, which I ſet down as the Anſwer to my Queſtion thus, *Facit* 13140000 farthings.

```
In one year 365  days.
             25
          -----
           1825
           730
          -----
In 25 years ,125 days.
             24
         ------
         36,00
        182,0
        -------
        219000 Ho.
            60
      ---------
      13140060  min.
```

Queſt. 2. *Pray tell me what theſe farthings come to in Pounds, Shillings, and Pence,* 1740120 *Farthings.*

```
              xxxx
xz            x7364x(6   x    (1
x7400xz|0    (435030    (3625|2 (1812
444444        xzzzzz     zzzz0
               xxxx
```

Four farthings make a penny, therefore I divide the whole Sum of Farthings by 4, and the Quotient is $\frac{1}{2}$ of the number of farthings, or the farthings reduced into pence, 435030 *d.* of which Sum I take the $\frac{1}{12}$ by dividing it by 12, which is the next Quotient (the number of ſhillings that is the farthings) which is 36252 *s.* 6 *d.* Twenty ſhillings make a pound, therefore I take the twentieth part of this laſt Product, by dividing it by 20, and that Quotient ſhall be pounds, and the remainder of the Diviſion ſhillings: 1812 *l.* 12 *s.* The Anſwer of your deſire I will ſet down thus: 1812 *l.*—12 *s.*—6 *d.*

Queſt. 3. *Some ſay that in a Mile there is* 1760 *Paces, three Feet being one Pace, twelve Inches one Foot, three Barley-corns being one Inch: I pray tell me how many Barley-corns will reach three Mi.*

Becauſe there is 3 miles, 3 times 1760 is the number of paces contained in 3 miles: then becauſe 3 foot is 1 pace, multiply 5280 by 3, and it produceth the number of feet that is in 3 miles; then becauſe 12 inches is a foot, multiply your feet by 12, and it produceth 190080, the number of inches contained in 3 miles: and becauſe 3 Barley-Corns make an inch, multiply your inches by 3, and it gives you the number of barly-corns that are in 3 miles, and the ſame is to be underſtood for any other number of miles.

	1760	
	3	
In 3 *Miles there is*	5280	*Paces.*
	3	
Feet in 3 *Miles*	15840	
	12	
	31680	
	15840	
3 *Miles in Inches*	190080	
	3	
In Barley-corns	570240	

Facit 570240 Barly-Corns in 3 *Miles.*

Suppoſe I would know how many Miles is in the ſame number of Barley-corns, namely, 570240 Barley-corns.

As before you multiplied to bring Miles into Barley-corns, ſo now divide to bring things of ſmall Denomination into great, only begin at the loweſt, where before you ended, for the demand of this is the beginning of the other.

Example.

```
               1
               2
2    2         724          2      21(0
570 24|0(190080(1584|0(528|(3 Miles.
333333    1222222    3333    2760
               1111
```

Here the Quotient of the firſt Diviſion is Inches, becauſe three Barly-corns make an Inch, namely, 190080 Inches.

The Quotient of the ſecond Diviſion is the number of Feet contained in thoſe Inches, (and therefore the Inches were divided by 12) namely, 15840 Feet.

The Quotient of the third Diviſion is Paces, and therefore it was divided by 3, the number is 5280 Paces.

The Quotient of the laſt Diviſion is the number of Miles contained in either 570240 Barly-corns, or 190080 Inches, or 15840 Feet, or 5280 Paces, which is 3 Miles, the thing required: And after the ſame manner you may reduce minutes into degrees, or ſeconds into minutes and degrees, or degrees into hours, pounds into ſhillings, ſhillings into pence, and pence into farthings, or the contrary, by knowing how many of the one makes one of the other.

The Proof of Reduction.

The Proof of Reduction is the ſame thing which we did laſt, I framed it ſo for brevities ſake. When you would prove any Sum that is brought into a ſmall Denomination (by Multiplication,) divide it backwards, beginning with the Product of your laſt Multiplication, and compare them in each as you do it, and if the Sum be right they will agree.

When you would prove any Sum that is brought into a greater Denomination (by Diviſion) then as before you divided, ſo now multiply; for I have ſhewed that Multiplication and Diviſion is the Proof one of the other.

Queſt. 4. *I will reduce* 28 *degrees* 20′ 40″ *into ſeconds.*

Firſt Multiply your degrees by 60, and it brings them into minutes, add your odd 20 minutes to that Product, and it makes the number of minutes in that given number of degrees and minutes: multiply that by 60, and it produceth the number of ſeconds contained in that given number of degrees and minutes: to that Product add your odd 40 ſeconds, and it gives the number of ſeconds contained in the degrees, minutes, and ſeconds, as here in this Example: and the reaſon is, becauſe 60 minutes is a degree, and 60 ſeconds is a minute: The ſame is to be underſtood of the reducing of any number of ſeveral Denominations into one.

82	*Degrees,*
60	
4920	*Minutes,*
20	*added.*
4940	*in all.*
60	
296400	*Seconds.*
40	*added.*
296440	*in all.*

Facit 296440 ſeconds in 28 degrees, 20 minutes, 40 ſeconds.

Thus much for what Mariners have need to know in Reduction.

Note, That the Remainder of any Diviſion either in Reduction, the rule of Three, or in any Diviſion, is ſome part of a Unit, namely thus: If the Quotient be ſhillings, the remainder is ſome part of a ſhilling: If the Quotient be pounds, the remainder is ſome part of a pound. The remainder is the Numerator, and the Diviſor is the Denominator of the Fraction; ſo that if the Quotient were pounds, and the remainder 12, the Diviſor is 20, and the Fraction is the $\frac{12}{20}$ of a pound, which is 12 ſhillings; the like for any thing elſe.

The Golden Rule, or *Rule of Three.*

THis Rule well underſtood, is the Sum of the reſt that follow it; for they are all (but as it were this Rule) it is called *The Golden Rule*, becauſe it is the Foundation of the reſt: It is called *The Rule of Three*, becauſe three numbers are given to find a fourth.

Now there is the Rule of Three direct, and the Back Rule of Three: the Rule of Three direct, is for ſuch queſtions as are ſo ſtated, that the third number and ſecond multiplied together, and that Product divided by the firſt gives the fourth.

The Back Rule of Three is ſo ſtated, that the firſt number and the ſecond are multiplied together, and that Product divided by the third, finds the fourth.

And this is all the diſtinction that I can make between the forward and backward Rule of Three, which is all the Rule of Three: I will not make therefore two diſtinct Rules of them, (but one) therefore pray obſerve this difference:

In all Queſtions in the Rule of Three there is three things given to find a fourth, which number will have alike proportion to the third, as the ſecond hath to the firſt.

In ſtating your Queſtion, be ſure let it be ſo that you may ſet your ſum in order with the firſt and third number, ſpeaking both of one thing: I mean if the firſt be Ells let the third be Ells; if the firſt be Degrees, let the third be degrees, or ſomething that Degrees can be reduced to.

If your Sum be ſet with the numbers in ſeveral Denominations, before you bring your Sum in order, you muſt reduce your numbers into the leaſt Denomination: As ſuppoſe your Sum was this, If 5 pound 10 ounces of Tobacco, coſt 10 ſhillings 9 pence, what ſhall 510 pounds coſt? Reduce your 5 pounds 10 ounces into ounces, and your 510 pounds into ounces: likewiſe your ſhillings into pence, taking in the odd pence and odd ounces, as I have ſhewed how to do it in page 16 and 17.

Your Sum being reduced (as I have ſhewed) into the leaſt Denominations, ſet it in order thus:

If 90 *Ounces coſt* 129 *pence, what coſts* 81600 *ounces*?

Your Sum being in order, conſider whether your third number require more or leſs: if it require more, multiply the ſecond number by the greateſt of the two extreams, and divide that Product by the leſſer, it produceth the fourth number in the ſame Denomination that the middle number was.

If your third number require leſs, multiply the middle number by the leaſt of the two extremes, and divide that product by the greateſt, and it gives your fourth number in the ſame denomination that your ſecond number was; then if you deſire to reduce it into greater Denomination, do it as I have ſhewed already.

For your better underſtanding of this Rule of Three, I have here following done an Example of it in right Lines, and have found it upon this Queſtion.

Queſt. 1. *If 10 pounds of Chocolato coſt 15 ſhillings the firſt penny, what ſhall 28 pounds coſt?*

Arithmetically.

If 10 l. *coſt* 16 s. *what will* 28 l. *coſt* ?

28
15
—
140
28
—
420

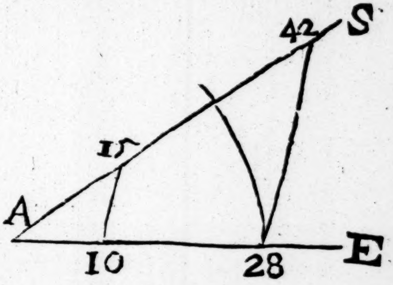
(2 s.
$\cancel{4}\cancel{2}(0(\cancel{4}\cancel{2}($ 2 l.
$\cancel{2}\cancel{0}\cancel{2}\quad\cancel{2}\cancel{0}$
$\cancel{1}$

Facit 42 s.
or 2 l. 2 s.

Here is no need of bringing things into lower Denominations, becauſe the numbers are in one Denomination already.

Geometrically.

Draw two lines that may touch one the other at pleaſure, as the lines A S and A E touch one an other in A, then upon the line A E, ſet 10 *l.* fixing one foot of your Compaſſes in A, (I take the 10 from a ſcale of equal parts) from the ſame ſcale I take 15 *s.* and fix one foot of my Compaſſes in A, and ſet it off upon the line A S, and draw a line from 15 to 10, then upon the line A E, I ſet 28 (from A) and from 28 I draw a line parallel to the line 10 15, then it is evident that if A 10 gives A 15, A 28 will give A 42, becauſe 42 28 is drawn parallel to 15 10, and the ſame holds in proportion: I marked it 42, becauſe it is 42 from A.



A line parallel to another, is when two lines go ſo evenly one by anoiher, that they be in all places equally diſtant.

Queſt. 2. *If* 27 *men rigg a Ship in* 8 *days, how many days ſhall* 20 *men be doing it ?*

```
                          men            days            men
          days            27 ———————————— 8 ———————————— 20
Facit 10 16/20            8                   2|16( 10
of a day or 3/4           216                 220
```

Here you ſee the laſt number required is more than the middle moſt, for 20 men muſt be longer about the work than 27 men, therefore I multiplied the middle number by the firſt, becauſe it is bigger than the third.

If in 10 days 16/20 of a day 20 men rigg a Ship, how many ſhall do it in 8 days ?

Here the number of days muſt both be brought into 20 of days (that is ſuch parts as 20 makes 1) which is done by multiplying the days by 20, now the reaſon is becauſe the firſt number is of ſeveral Denominations, and muſt be brought into the loweſt; which is the Denomination here mentioned.

```
    10 16/20 ——————————————————————————————— 8
    20                                       20
    ——                                       ——
    200                                      160
     16                                      ——
    ——                 men
If  216 ———————————————20 ——————————————— 160
     20           14
   ———             21|0
   4320           4320( 27 men Facit.
                  1600
                   16
```

This is the other Sum ſet backwards as it were, and you ſee it produceth the ſame number that was given to do it in 8 days before, which aſſures you that your other work is right, and this is the way the Rule of Three is proved.

Queſt. 3. *If in four hours the Sun goeth* 60 *degrees, how far ſhall he go in* 24 *hours?*

If 4 hours give 60 degrees, what ſhall 24 hours give?

```
                         20           60
Facit 360 degrees.     1440 (360     ----
                         44          1440
```

I need not prove this Sum, or any other, but leave it to your own practice to ſet it backwards and do it.

If 22 *deg.* 30 *min.* of the Horizon be two points of the Mariners Compaſs, how many points is 360 *deg.*

```
 deg.      min                 points.             deg.
  22 ------ 30 ---- --------- --- 2 ------- ------ 360
  60              21                                60
 ----             1470                           ------
 1320             43200|0(32 Facit 32 points.     21600
   30             13500                               2
 ----             135                            ------
 1350 min.                                        43200
```

360 *deg.* is the Circumference of the Horizon or of any Circle, and the Mariners have 32 points, that they have names to in the Compaſs, and no more; then from hence it is evident that 11 *deg.* 15 *min.* is one point, 22 *deg.* 30 *min.* is two. 33 *d.* 45 *m.* three, and ſo forth.

I might be large in handling Arithmetick, but it is a thing that hath been very well handled by Mr. *Record*, and lately by Mr. *Hodder*, whoſe Works are cheap and very admirable: I ſhould have ſaid nothing of this Subject, if I had not found the want that Sea-men have of it, by daily experience in them which I have taught: and ſeeing I have perſiſted thus far, I will but ſhew how every Rule that followeth is worked from this Rule of Three.

The Backward Rule you ſee is it.

The Rule of Practice is the Rule of Three abbreviated.

The Rule of Proportion, ſometimes called the Rule of five Numbers, or by ſome the double Rule from its double working, is nothing but the Rule of Three

The Rule of Intereſt is the Rule of Three, as alſo Intereſt upon Intereſt.

The Rule of Fellowſhip is the Rule of Three, I'll do Examples of no more, but all Rules depend upon it: I'll begin with the Rule of five numbers.

Queſt. 4. *If* 100 l. *in* 12 *Months gains* 6 l. *what ſhall* 900 l. *gain in* 24 *Months* ?

If 12 Months gain 6 *l.* what ſhall 24 Months gain? I work the proportion before-mentioned, and I find that 100 *l.* will gain 12 *l.* in 24 Months.

Then I ſay if 100 *l.* gains 12 *l.* what ſhall 900 *l.* gain in the ſame time? If you work it you will find it will gain 108 *l.* and this is the Rule of Three, for firſt you ſee what 100 *l.* will gain in the time that is ſet to 900 *l.* (provided it get 6 *l.* in 12 Months) and then you ſee what 900 *l.* will gain in the ſame time, (provided that 100 *l.* gains ſuch a proportion as you find it to do.)

The Rule of Intereſt, and Intereſt upon Intereſt.

THis is the Rule of Three, for it runs thus:

Queſt. 1. *I let* 478 l. *for two years, what ſhall the Uſe of it come to, after the rate of* 6 l. *a year, for the lent of* 100 l. *which is the common Uſe of it in a year.*

I'll ſet my Queſtion in order thus:
If 100 *l.* gives 6 *l.* what ſhall the principal 478 give?
Facit 28 *l.* 68 $\cancel{2}8$ (68 (28 6
— $\cancel{1}\cancel{1}00$ —
100 2868

Here we have found what the Principle hath gained for a twelve-month, next conſider what proportion 12 Months is to the time your money was lent, which was 24 Months: now if it had been three times as long a time as 12 Months, you muſt have made it 3 times as much as you find it for 12 Months, but being but twice as much, you muſt make the Uſe to to be twice 28 $\frac{68}{100}$ which is 57 *l.* $\frac{36}{100}$ of a pound; the ſame is to be underſtood of any number elſe; but in ſtead of ſeeing what proportion the time limited for the lent bears with 12 Months, you may work it as you do the Rule of five Numbers, by ſaying (after you have abbreviated your Fraction.)

If 12 Months give 28 *l.* $\frac{68}{100}$, what ſhall 24 Months gain? But I ſay the other way is beſt, after your other manner; If it had been one fourth of the time, it would have been $\frac{1}{4}$ of the uſe; if one fifth of the time, $\frac{1}{5}$ of the uſe. For it ſtands to reaſon, that if 100 *l.* or any other quantity gains 6 *l.* in twelve Months. it gains four times as much in four times the time, or five times as much in five times twelve Months, and ſo forth.

I might ſay ſomething of Intereſt upon Intereſt, but that differs but little from this: At the years end, add in your ſimple Intereſt to your Principal, and make it one entire Sum till the next year, then add that Intereſt to the Principal the year before, and receive the Intereſt of it: this is all it differs from the former.

The Rule of Fellowſhip.

THis Rule is the Rule of Three, done ſeveral times in one Sum or Queſtion: for here are ſeveral Stocks, and ſeveral men that own them; now if the principal, or all their Stocks gain ſo much, how much ſhall each man gain according to the Stock he put in? I'll ſay, if the whole Stock gained ſo much, what ſhall the firſt mans Stock gain? and ſo for the reſt.

Queſt. 1. *Six men make a Stock, the firſt puts in* 30 l. *the ſecond* 40. l. *the third* 52 l. *the fourth* 58 l. *the fifth*

60 l. *and the ſixth* 78 l. *If the whole Stock together gains* 200 l. *what ſhall each man have, ſo that there may be no wrong?*

Firſt, find the whole Stock by adding every mans Stock together, which is 318 *l.*

Then ſay, If the whole Stock 318 *l.* gains 200 *l.* what ſhall the firſt mans Stock gain?

	l.
Firſt	30
Second	40
Third	52
Fourth	58
Fifth	60
Sixth	78
	318

For the Second.

If the whole Stock 318 *l.* gains 200 *l.* what ſhall 40 *l.* gain, which is the ſecond Stock?

The like is to be underſtood of the reſt: I forbear to work them, as being out of my intentions: I leave their operation to your genius who never learned them.

Queſt. 2. *There where five men made a Stock, the firſt put in* 200 l. *the ſecond* 59 l. *the third* 180 l. *the fourth* 78 l. *the fifth* 240 l. *they loſt at the return of the Ship* 120 l. *I demand each mans Loſs proportionable to his Venture?*

Firſt find the whole Stock, by adding every mans Venture together: this done, ſay for the firſt mans Loſs, if the whole Stock loſt 120 *l.* what ſhall the firſt mans Stock 200 *l.* loſe?

For the ſecond, If the whole Stock loſe 120 *l.* what ſhall the ſecond man loſe which put in 59 *l*?

And ſo for the reſt: The way to prove one of theſe Queſtions is leſs trouble than the Rule of Three, for after you have done, add all your *Facits* together, and it will make the ſame that was loſt in the whole Stock, or gained in the whole Stock, (if the Queſtion be for Gain) and this ſtands to good reaſon; for every mans Loſs or Gain muſt together be equal to the whole, or elſe they do not contribute to the Loſs, or enjoy the Gain that they have loſt or gained.

There is more intricacy in this Rule than I have here cited, but the Foundation-work lies on the Rule of Three, and the intricacy that I ſpeak of, will be underſtood with ſome conſideration: I had thoughts to have ſhewed it, but it is ſhewed as well as can be (I think) by Mr. *Record* and Mr. *Hodder*: beſides it would take up much paper, and I ſhould digreſs from my intentions to Navigation.

What I have ſhewed ſince I treated of the Rule of Three, is only a ſhew how all Rules depend upon this Golden Rule. Blame me not for being ſo large in Arithmetick; but both that, and all faults elſe, ſeaſon with the Salt of a charitable Conſtruction, remembring that Navigation is imperfect without it, I end.

GEOMETRY.

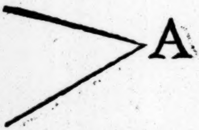
THat which I ſhall handle in Geometry, will be only that part of it which is uſed in Navigation: He that will treat of it at large, had beſt to put it in a Treatiſe by it ſelf, and he that will learn to be a good Geometrician, let him apply himſelf to *Euclid's* Works. There is no Art but hath a dependency on it, and Navigation depends much on it, which enforceth me to treat upon ſome principles of it.

Geometrical Definitions.

A *Point* or Prick is this. (.) and is void of length, breadth or thickneſs.

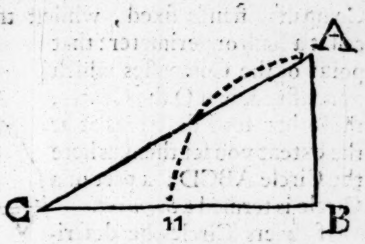
A *Line* is length without bredth or thickneſs, and is properly called the neareſt diſtance (if a ſtreight line) between two places: but if not ſtreight but circular, it is termed an Arch.

An *Angle* is when two lines are ſo drawn that they will meet, not in one ſtreight line, but one to croſs the other: now the place where they croſs or interſect, is called the *Angular Point*, as in this figure A is the *Angular Point*. All Angles that are bounded by ſtreight lines, are called *right lined Angles*, as the Angle A.

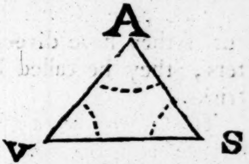


A *Triangle* is when three lines meet, making three angular points; now there be two ſorts, right lined, and ſpherical: ſpherical being all the ſides Arches of great Circles. There be three ſorts of Angles, namely, obtuſe, acute, and right angles.

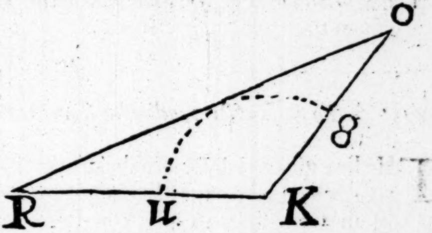
A *right angled Triangle*, is when a line is drawn from another line, ſo exactly upright, that it leans neither one way nor other, as you ſee the line A B and B C doth: alſo the Arch which is bounded between them two ſides, will be a quarter of a Circle, as n A is: the line C A being drawn makes it a right angled right lined Triangle, whereas before it was but a right Angle.



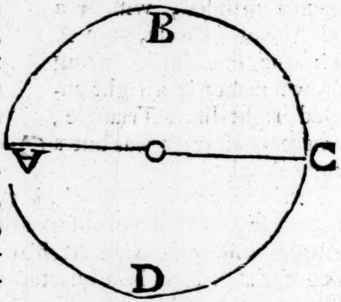
An *acute angled Triangle*, is when the ſides lean ſo one to the other, as that none of the three Angles will contain an Arch of 90 degrees, which is a quarter of a Circle, but will be all leſs, as you ſee in the acute angled Triangle V S A.



An *obtuſe angled Triangle* is when the lines are ſo drawn, that one of the Angles is bounded by above a Quadrant, or the $\frac{1}{4}$ of a Circle, as is the Angle at K, ſee 8 u is above $\frac{1}{4}$ of a Circle: whatſoever part of a Circle any Angle bounds, that Arch is the meaſure or contents in degrees or points of that Angle, as the Arch u 8 is the meaſure of the Angle at K, the Center of the Arch is K. When in writing we would expreſs an Angle in letters, we ſet the middle letter for the Angle that is meant, as here O R K is the obtuſe Angle at K. The Complement of an Angle or Arch, is what it wants of 90 degrees or a Quadrant: or ſometimes (if need require) what it wants of a Semicircle, which is twice 90 or 180 degrees.



A *Circle* is a plain figure, ſwept out by a pair of Compaſſes from the Center, which is the place where one foot of the Compaſſes ſtands fixed, whileſt the other deſcribes it; ſome call it a limb or perimeter: that point of the Compaſſes which ſtands fixed, is at O the Center, the other foot deſcribes it at the extent you ſet them, as here the Circle ABCD: a part of a Circle is termed a *Segment.*



If divers Circles be deſcribed having all one Center, they be called Concentricks, but if they have divers Centers, they be called Excentricks.

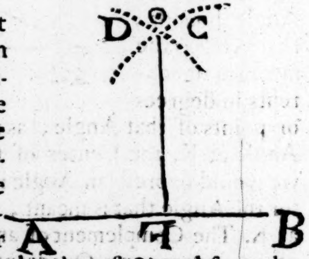
The *Circumference of any Circle* conſiſts of 360 degrees, every degree being 60 minutes.

The *Diameter of a Circle* is a line drawn from one ſide of the Circle to the other through the Center, As A C.

The *Semidiameter of a Circle* is half the Diameter, or the diſtance from the Circumference to the Center.

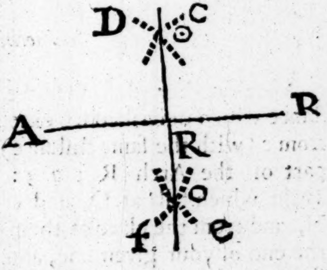
PROP. I. *To raiſe a Perpendicular from the middle of a Line given*

THe line given is A B, divide it into two equal parts at F, then open your Compaſſes to any convenient diſtance (above half the length of the given line) and fix one foot in B, and with the other deſcribe the Arch C (with the ſame diſtance) fix one foot of your Compaſſes in A, and croſs the other Arch by the Arch D (mind where they interſect) and from that place (which is ⊙) draw a line to the middle of your given line A B, namely to F, then is F ⊙ a true perpendicular from the middle of the line A B, for it is ſo directly from it, that it leans no way.



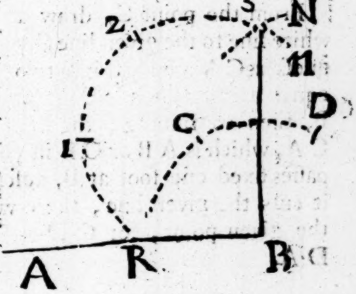
PROP.

PROP. II. *To divide a Line into two equal Parts by a Perpendicular.*



THe given line is AB, fix one foot of your Compaſſes in A, and ſetting them at any convenient diſtance, above half the given line, deſcribe the Arches D and f, carry your Compaſſes to B (with the ſame diſtance) and deſcribe the Arches C and e, ſo as they may croſs the other Arches as they do in ⊙, mind it, and by thoſe interſections lay your ſcale, and draw the line ⊙⊙, which will cut the given line in the middeſt, and be a perpendicular to it, which was required.

PROP. III. *To raiſe a Perpendicular to the end of a Line given*

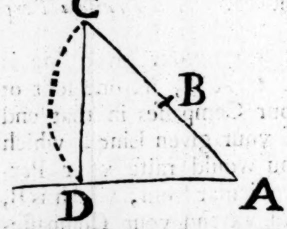


HEre your given line is A B, fix one foot of your Compaſſes in that end of your given Line, which you would raiſe your Perpendicular from, which is B, and extend your Compaſſes to any convenient diſtance, (as in the example, from B to R) and deſcribe the Arch R c D, (continue the ſame diſtance in your Compaſſes) and fix one foot in R, extend the other upwards to c, then making c the Center, deſcribe the Arch 1, 2, 3, and beginning at R, ſet off that diſtance three times upon that Arch, as 1, 2, 3; from the place where your Compaſſes fall the third time, (which is 3) draw a line to the place where you began your work, which is B, and it is a Perpendicular to your given line.

Another way.

After you have deſcribed the Arch R c D, (with the ſame diſtance which deſcribed it) extend your Compaſſes from R to c: from c (with the ſame diſtance) deſcribe the Arch u: which is part of the Arch R 1 2 3: then extend the ſame diſtance again which falls at D, and croſs the Arch before deſcribed as N, and from the place of their interſection, draw your line to the end of your given line, and it ſhall be a Perpendicular: you ſee it is the ſame the other was.

PROP. IV. *To let fall a Perpendicular from a Point to a given Line.*



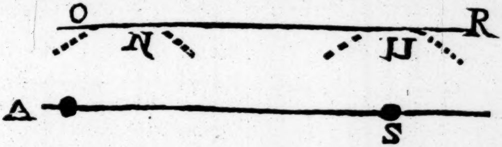
Let the given line be D A, the point from whence the Perpendicular is to be let fall, be at C.

From the point C, draw a white line to the given line (by gueſs) as C A, divide it into two equal parts, which is done at B, then continuing ½ the line C A, which is A B or C B in your Compaſſes, and your Compaſſes fixed one foot at B, deſcribe the Arch C D, and where it cuts the given line, there will your Perpendicular fall from the given point, for C D is Perpendicular to the given line D A.

PROP.

PROP. V. *To draw a Line parallel to a Line given.*

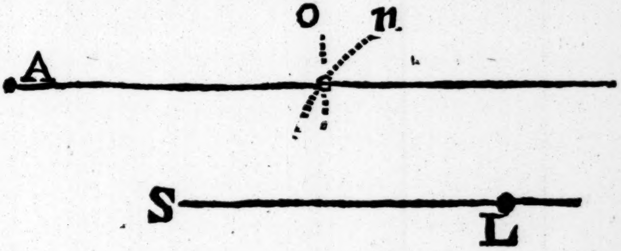
Let the given line be AS: It is required to draw a line ſo, that the two lines may run (at both ends) one by the other and never meet, which is parallel one to the other. Open your Compaſſes to that extent as you would have the two lines aſunder, and go towards one end of the given line as at S, and



deſcribe the Arch u, and with the ſame diſtance come towards the other end as at A, and deſcribe another Arch which is N, and by the top of theſe two Arches draw the line RO, which is parallel to AS.

PROP. VI. *To draw a Line parallel to a given Line, from any Point aſſigned.*

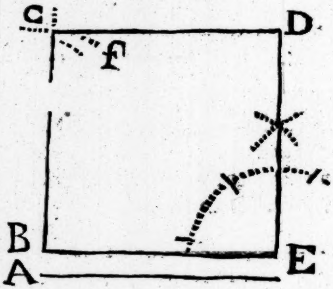
Let the given line be SL, the point aſſigned be A, take the diſtance from S to A, and carry it towards the other end of the given line as at L, deſcribe the Arch n, then take the diſtance from L to S, and fixing one foot of your Compaſſes in



the given point A, croſs the Arch n with the arch o, and by the place of their interſection, and the point aſſigned draw a line, which ſhall be parallel to S L.

PROP. VII. *To make a Square of a Line given.*

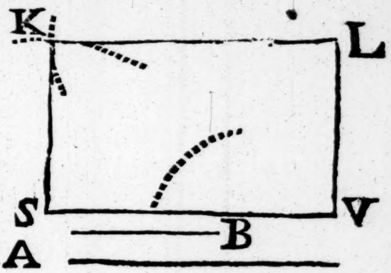
LEt the Line given be A, equal to which draw the ſide of the Square B E, and from one end of it raiſe a Perpendicular, and by it ſet off the length of A, as here from E the Perpendicular was raiſed, and the length of A ſet upon it, which is the ſide of the Square E D, continue the ſame diſtance in your Compaſſes, and go to D, and deſcribe the Arch 8: carry the ſame diſtance to B, and croſs the Arch 8 with f, and from the interſection of thoſe two Arches, draw the ſides C D and C B, which makes the Square BEDC, & this is a true ſquare.



PROP. VIII. *To make a Square, whoſe Length and Bredth is given.*

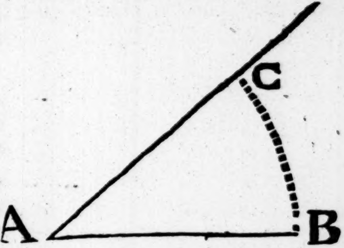
THeſe ſorts of Squares are called *Geometrical Squares*, when but two ſides are equal: namely, the two longeſt ſides, or the two ſhorteſt ſides: The Angles are all equal, namely right Angles.

Suppoſe the Length of the Square be A, the bredth B, I deſire to make it: firſt draw a line equal to A (for the length of it) as S V, then from any end of that Line raiſe a Perpendicular (as here from V) and ſet off the line B for the bredth of it (upon it) which falls in the Perpendicular line at L, then take the length of A, and deſcribe the Arch n, (fixing your Compaſſes one foot in L) then take B the bredth, and croſs that Arch by another, fixing your Compaſſes (one foot) in S, and draw L K, and K S from the place of their interſection, as you did in the other: Thus the two oppoſite ſides in this Square are equal, and the Angles in both all equal, for they are right Angles.

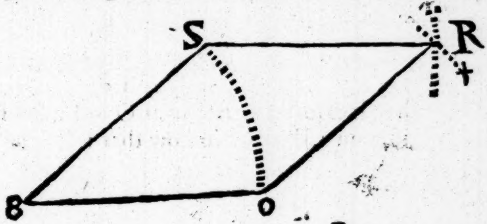


Prop. IX. *To make a Diamond Figure of a Line, and an Angle given.*

A Diamond Figure is a Figure of four equal ſides, but the Angles are two of them acute, and two of them obtuſe, the acute Angles are equal, and the obtuſe Angles are equal one to another.



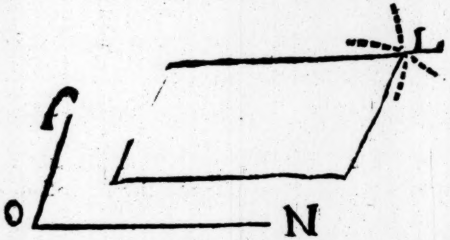
Let A B be the given line, C B the meaſure of the given Angle, (A being the angular point) firſt take the line AB, and draw a line of its length, for one ſide of the figure (namely 8 o) then take the Semidiameter of the Arch C B which is C A, and fixing one foot of your Compaſſes in 8, deſcribe the Arch S o, and take



the Arch BC, and ſet it off from O to S, then draw the line S 8 equal to 8 O, this done, keep the length of O 8 in your Compaſſes, and from S and O deſcribe the Arches n and t, and draw the ſides OR and SR, as you did in the other figures, and thus SR is equal to 8 O or R O is equal to 8 S, and the oppoſite Angles alſo equal. I forbear to ſhew the reaſons of their being equal, becauſe it hath been handled by others, and indeed it is ſo plain, that with a little conſideration you may know it.

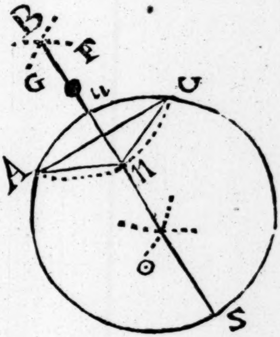
Prop. X. *To make a Rhomboiades of two given ſides, and an Angle included.*

A Rhomboiades is a figure whoſe oppoſite ſides, and oppoſite Angles are equal (as a Geometrical Square is) but in this they differ: a Rhomboiades hath never a right Angle, but two obtuſe, and two acute, whereas the other hath all right Angles; it differs from the Diamond figure alſo; for in one the ſides are all equal, and in this but two equal ſides: I need not ſhew the working of it, becauſe it differs not from a Diamond figure only in taking the two ſides apart, to deſcribe the Arches at L;



I ſuppoſe you may conceive how it is made, by ſeeing this which is here made: the given ſides and Angle is f O N, I have not ſet down the Arch to meaſure the Angle at O. I ſuppoſe from what hath been ſaid, you will conceive how that is.

PROP. XI. *To find the Center of a Circle.*



ADmit the given Circle be S A u C and I would find the Center of it.

Draw a line from ſide to ſide of the Circle at a venture, as A C, and divide that line into two equal parts by a Perpendicular (as was ſhewed before) that Perpendicular line draw through the Circle from ſide to ſide, as is u S, and it ſhall be the Diameter of the Circle, the half of which is the Semidiameter or very Center ⊙.

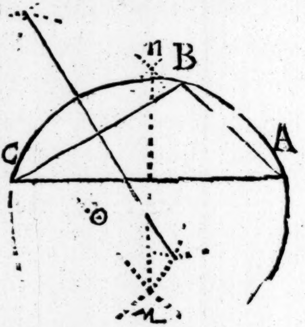
It is poſſible to find the Center of a Triangle after the ſame manner: Suppoſe the Triangle, whoſe Center you would find were A C n, divide any ſide into two equal parts by a Perpendicular, and it will go through the Center of the Triangle, as the ſide A C is divided into two equal parts by the Perpendicular B S; then, I ſay, B S goeth through the Center of this Triangle; but to find whereabouts in this Perpendiculer the Center of the Triangle is, I know by no other means, but by removing your Compaſſes in this line, from place to place till you find it, which is here found to be at u.

But this is but a botchingly way, and with a little more labour you may find it at once, therefore mind this Geometrical Example.

Prop.

Prop. XII. *To find the Center of a Circle, of a Triangle, or any three Pricks that be not in a ſtreight Line.*

THe given Triangle is A B C, divide the longeſt ſide A C into two equal parts by the Perpendicular n m, then divide either of the other two ſides into two equal parts by a Perpendicular (here the ſide B C is divided) and where theſe two Perpendiculars interſect one another, there is the Center of your Triangle, namely ⊙, if it had been a Circle you might have made three pricks for the three Angles, and imagined the diſtance between thoſe pricks to be the ſides of the Triangle, and proceeded as you did here, and the Center of thoſe three pricks, muſt have been the Center of the Circle, becauſe they were all in the Circumference, or Sweep it ſelf.

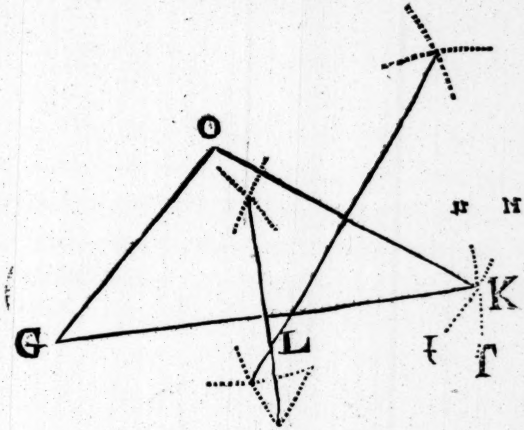


Here might be ſeveral Queſtions deduced from this Demonſtration, but I'll content my ſelf with one, and leave others that might be framed to your conſideration.

Queſt. *I have a Piece of Ground that hath three conveniences in it, which be theſe; the firſt is a Garden, now the Gate of this Garden is diſtant from a Gate that leads into an Orchard 300 Yards, that Gate is diſtant from the head of a curious River 350 Yards: Now if the head of this River be diſtant from the Garden-Gate 500 Yards, I demand where I may build me a Houſe that may ſtand of a like diſtance from theſe Places, and how far it ſhall be from them?*

I conſider that theſe places cannot be in a ſtreight line, becauſe then the Houſe will not be of an equal diſtance from thoſe Conveniences, and therefore if lines be drawn from one place from another, it will make a Triangle.

The Operation.



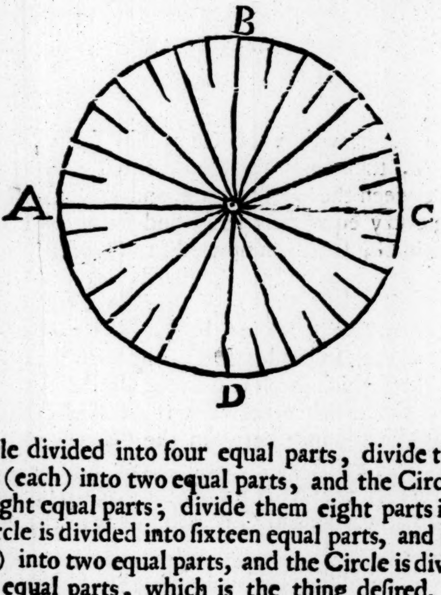
Make a prick with your Compaſſes for your firſt ſtation, which is G, then from a Scale of equal parts, take off the diſtance between the Garden-gate, and the Orchard-gate 300, (counting every equal part 100) and fixing one foot of your Compaſſes in G, ſet them upwards to O, which is the diſtance between the Garden and the Orchard, then take the diſtance between the Orchard-gate O and the River, which is 350 yards (or three equal parts and an half) and fix one foot of your Compaſſes at the Orchard-gate O, and with the other deſcribe the Arch n t (which Arch will ſweep the head of the River) laſtly take the diſtance between the firſt place and the third, (which is the diſtance between the Garden and the River) 500 yards or 5 equal parts, and fix one foot in G the Garden-gate, and croſs the Arch n t by the Arch u ſ, and draw the ſides OK 350 yards, and GK 500 yards to the place of their interſection.

Now becauſe this Houſe is to be built of an equal diſtance from every of theſe places, therefore the Center of theſe three Conveniences (which are repreſented by the three pricks OK

O K and G) muſt be the place where the Houſe muſt be built, which is at L, and the reaſon is, becauſe the diſtance between the Center and any part of the Circumference is alike: I have ſhewed already how to find the Center.

Prop. XIII. *To divide the Circumference of a Circle into 2, 4, 8, 16, 32 equal parts.*

THe Circle to be divided is ABCD; firſt draw a line parallel (if you will) to the bottom of your Book as AC, through the Center ⊙, which divides it into two Semicircles, divide that line into two equal parts by a Perpendicular (which Perpendicular will fall through the Center) it is BD, then is the Circle divided into four equal parts, divide them four equal parts (each) into two equal parts, and the Circle is divided into eight equal parts; divide them eight parts into two, and the Circle is divided into ſixteen equal parts, and them ſixteen (each) into two equal parts, and the Circle is divided into thirty two equal parts, which is the thing deſired. This is ſufficient in Geometry for our uſe in Navigation.



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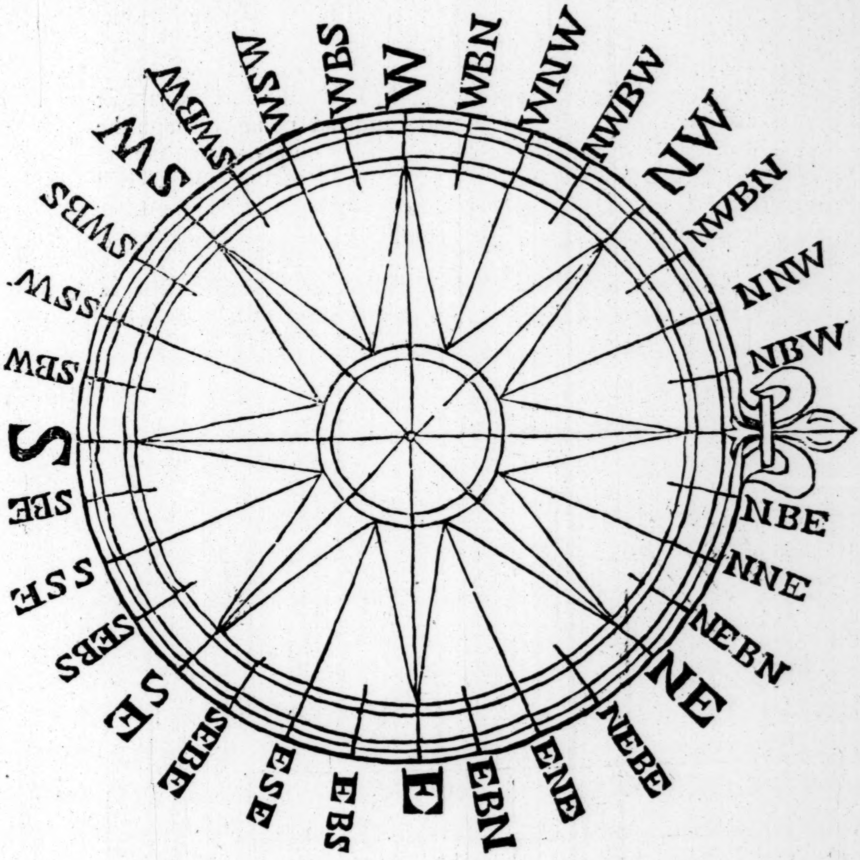
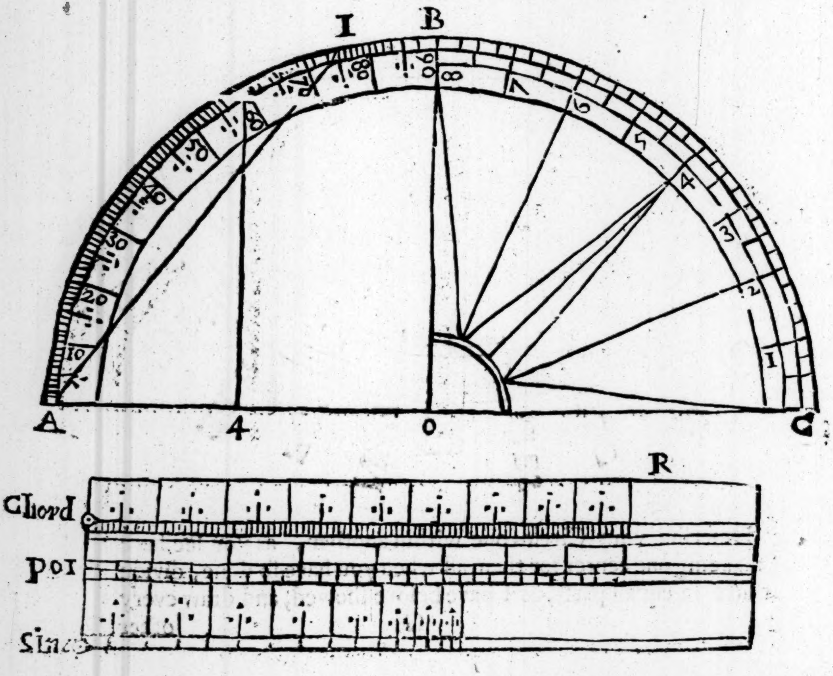
The Projection of the Mariners Compaſs.



Deſcribe your Circles one within another, as you ſee here (makeing one center for them all when you have ſo done, divide it into 32 equall parts, as I have before ſhewed, and draw every other point to the inner Circle, the reſt to the fourth Circle) thus the Compaſs is made. If you have a deſire to divide it into half points, divide the whole ones into two equal parts round about, and draw them to the third Circle; if into quarters, divide your halfs into two equal parts, and draw them to the ſecond Circle: draw none but the North and South, Eaſt and Weſt, Northeaſt and Southweſt, Northweſt and Southeaſt points through the center. For drawing the points, it is but obſerving to make the North point a whole point, and the other ſeven great points will fall by courſe (if you obſerve to make a great point of every other from the North point.) It is common for a Circle without all this to be divided into 360 deg. and then you may ſee how 11 deg. 15′ is a point of the Compaſs. But I have proved that in Arithmetick, which ſaves me a labour here to do it.

The Projection of the Plain Scale.



Deſcribe a Semicircle upon the line A C (if you are minded to have your Scale large, let your Circle be large, for the Scale will be according to the Circle) and divide it into two equal parts by the Perpendicular B o: the one of theſe Quadrants divide into 8 points of the Compaſs, the other Quadrant, namely B A, divide into degrees, which is done by dividing it into 9 equal parts, and every one of them parts into 10 equal parts, which is 90 degrees for the Points of the Compaſs, they are ſhewed ſufficiently before. Suppoſe your Scale were gaged fit for your turn, namely, a place to ſet the line of Chords, a place to ſet the line of Sines, and a place to ſet the Points of the Compaſſes: (there are Lines of Longitude, and Tangent lines, but we ſhall meddle with neither of them at this time, becauſe without them theſe will be ſufficient with a Scale of equal parts.)

For the Line of Chords.

THe Chord of an Arch is that quantity of a Circle that is between the two ends of a line that is drawn from one part of the Circumference to the other, as the line A 1 is the Chord of 75 degrees (for every pricked Diviſion is a fifth) and ſo a ſtreight line drawn from A to 10, is the length of the Chord of 10, a line drawn from A, to 20 degrees is the Chord of 20 degrees, and ſo of the reſt. Now your Circle being thus divided, take of every degree, as I have, and apply it to your Scale.

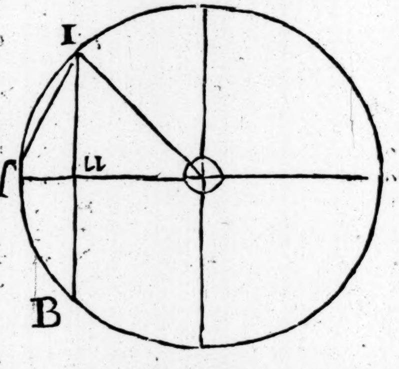
For the Points of the Compaſs.

THey are taken off after the manner of a Chord: firſt C 1 for one Point, then C 2 for two points, and ſo of the reſt; but you muſt be ſure to take your Line of Chords and Points of the Compaſs from one and the ſame Arch (namely, the uttermoſt) elſe they are not proportionable (which they muſt be) take off every quarter in the manner as you took the degrees of Chords.

For the Lines of Sines.

A Sine of an Arch is always half the Chord of twice that Arch, as my Father ſheweth in his *Deſcription of a Sine*, (p. 2. of his *Trigonometry*, Book 1.) It is the neareſt Diſtance between the place you have a deſire to meaſure, and a line from the other place that goeth through the Center of the ſame Arch (which is a Perpendicular let fall to it) namely 460 is the meaſure of 60 degrees (the Arch A 60). For your better underſtanding, obſerve this following Example for both a Chord and a Sine.

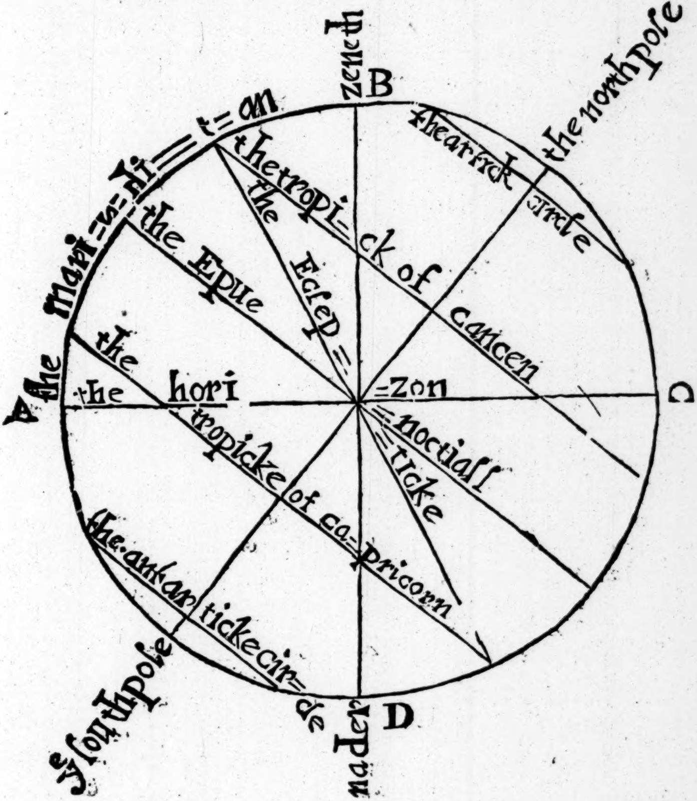
Admit I would take the Sine of the Arch ſ I in this Scheme, from either ſ or I, I'll draw a Line to the Center of the Arch ⊙, which is ſ ⊙ drawn from ſ from the other end of the Arch I, I let fall a Perpendicular upon that line which is I u; then is the length of I u the Sine of the Arch I ſ: but for brevities ſake we uſe to fix our Compaſſes one foot in I, and extend the other juſt to ſweep the line that goeth through the Center ſ ⊙, which is the length of the Perpendicular I u. If I were to take the Chord of the ſame Arch, the line ſ I is it, and theſe two lines are fit to apply to a Scale of Sines or Chords (to find that Arch) provided that the Semidiameter of the Arch be the ſame that the Scale was made by: and this is evident then, that if two lines be extended to the Semidiameter of the Arch the Scale is made by (which we call the Radius) then the meaſure of the Arch that is cut between them two lines, is the Chord of the Angle contained between them lines, as ſ I is the Chord of the Angle I ⊙ ſ.



Or if one of then be extended to the Radius (as is ⊙ I) and the other ſo far that the perpendicular is let fall upon it (as ⊙ u) that perpendicular is the Sine of the Arch included between theſe ſides.

The Sine of an Arch is half the Chord of twice that Arch, as I u is the Sine of the Arch I ſ, and is half I B, the Chord of the Arch I ſ B, which is twice I ſ.

The Projection of the Sphere in Plain Lat. 50 deg.



There be many that do not attain to the Doctrine of Spherical Triangles, and are loth (indeed or cannot) ſpend time to ſtudy them: I have thought good to ſhew the way to meaſure any thing that is uſeful for Seamen by the plain Scale (before made:) and though this cannot be ſo exact as to come to a minute of a degree, yet it is exact enough for our uſe at Sea: For in taking an Azimuth, or Amplitude, or ſuch like, half a degree of the Compaſs will not make your Courſe the worſe (after you have allowed for Variation) it being not full the 22th. part of a point, which is no ſenſible error in ſteering: or for finding the length of the day (for ordinary uſes) it will breed but little error, 30 minutes being but 2 minutes of time; but for other things that require exactneſs to a minute or leſs, of a degree, this way is of no conſiderable uſe; the way by the Tables being exact, and ſo better. (I ſhall do both) The reaſon I handle this here, is in order to Navigation, that you may underſtand the Circles of the Sphere. This by way of Advertiſement.

Before I ſhew how to project the Sphere, it will be neceſſary to underſtand the Circles of the Sphere.

A Sphere is a Scheme or Figure which repreſents the Heavens, and therefore is round exactly, though upon a Plain it doth not ſeem ſo; from whence it is evident, that the lines here drawn in it cannot be ſtreight lines, but Circles: Now there are two ſorts of Circles, namely, the Greater Circles, and the Leſſer; the Greater Circles are ſuch as go round the very Body of the Globe, and ſo cut through two oppoſite points, dividing it into two Hemiſpheres, and are ſix in number, which are theſe:

1. *The Axis of the World.* *(From South to North Pole.)*
2. *The Horizon.*
3. *The Æquinoctial.*
4. *The Ecliptick.*
5. *The Eaſt and Weſt Azimuth.*
6. *The Meridian.*

The ſmaller Circles of the Sphere, are all ſuch Circles as do not divide the Sphere of Heaven into two Hemiſpheres, and ſo are leſs than thoſe that do; and they be four, namely, The two Tropicks, and the two Polar Circles, which to diſtinguiſh the Southermoſt from the Northermoſt, we call the Southermoſt Tropick, *Capricorn*; the Northermoſt, *The Tropick of Cancer*; the Southermoſt Polar Circle, *The Antartick*; and the Northermoſt, *The Artick Circle.*

All Circles that cut through the two Poles of the World, are called Meridians; and are alſo Great Circles, becauſe they divide the Sphere into two Hemiſpheres, cutting in two oppoſite points: it is certain, if a Circle goeth through two oppoſite points, it is as great a Circle as that globous Body can bear, and muſt divide that Body into two Hemiſpheres, as doth the Meridian A B C D.

The Poles are two oppoſite places in the Heavens, and are the ends (as it where) of that Line called the Axletree, which the Heavens may be imagined to turn upon: here that Line is called the *Axis of the World.*

The Æquinoctial is a Great Circle of the Sphere, which lieth between the Pole ſo equally, that its diſtance from either Pole is 90 degrees (the half of the diſtance between the Poles) and becauſe it is ſo equal between them, there begins Latitude; ſo that whatſoever Latitude you are in, ſo many degrees and minutes the Æquinoctial is below that part of the Heavens which is right over your head, and is called the Zenith; or from being right under you, which is called the Nadir. All Meridians cut this Æquinoctial at right Angles.

The Eaſt and Weſt Azimuth is a Great Circle of the Sphere that cuts through two oppoſite points of the Heavens, namely, the Zenith and Nadir: it alſo cuts the Horizon at right Angles in the points of Eaſt and Weſt; and therefore is called the Eaſt and Weſt Azimuth: all Azimuths are great Circles and cut the Horizon at right Angles.

The Horizon is a Great Circle of the Sphere, and divides that part of the Heavens which we do not ſee, from that part which we do ſee: or it is the furtheſt part of the Heavens which we can ſee for the Body of the Sea; it is only to be ſeen at Sea, or upon the ſhore where there is no land between you and it, and ſo you have divers Horizons according to your motion, for as you raiſe one part of the World, you lay the other.

The Zodiack is a great Circle, it is the bounds of the twelve Signs: now in the middle of it is the Ecliptick Line, in which Line the Center of the Sun goeth, and paſſeth every day its motion of Declination, till it comes to its utmoſt bounds, which is to the Tropicks: it cuts the Æquinoctial in two oppoſite points, and makes from theſe points an Angle of 23 *deg.* 30 *min.* which is the Angle S R t, ſo the Sun is never out of it. The twelve Signs divide this Ecliptick into twelve equal parts, and to every Sign theee is a Name, and a Character for that Name, and a Month to that Sign; which for your better knowledge I have here following inſerted.

The Names and Characters of the twelve Signs, with the Months they belong to.

March	*Aries*	♈	Theſe be the Northern Signs
April	*Taurus*	♉	
May	*Gemini*	♊	
June	*Cancer*	♋	
July	*Leo*	♌	
Auguſt	*Virgo*	♍	
September	*Libra*	♎	Theſe be the Southern Signs
October	*Scorpio*	♏	
November	*Sagittarius*	♐	
December	*Capricornus*	♑	
January	*Aquarius*	♒	
February	*Piſces*	♓	

Six of theſe be Northern Signs, and are in the North part of the Zodiack; and ſix of them are Southern Signs, becauſe they be in the South part of the Zodiack. The twelve Signs are twelve Conſtellations, the Months anſwering to them are agreeable. Thus much for the great Circles of the Sphere.

The ſmaller Circles are the Polar Circles and the Tropicks.

The Polar Circles are diſtant 23 *deg.* 30 *min.* from the Poles, and between them and the Poles is counted the Frozen Zones.

The Tropicks are the bounds of the Suns Declination, and they go parallel to the Æquinoctial (and 23 *deg.* 30 *min.* from it) the Tropick of Cancer being 23 *deg.* 30 *min.* to the Northwards, the Tropick of Capricorn being as far to the Southwards, which is the Suns furtheſt diſtance from the Æquator at any time.

How to Project a Sphere.

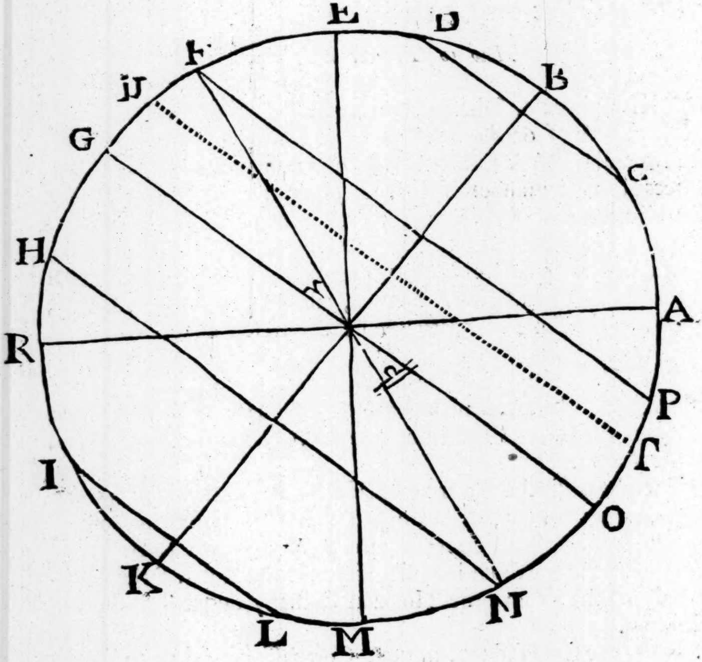
THis Sphere or Scheme is projected on this wiſe: Firſt, take an Arch of 60 *deg.* from your Scale of Chords, and deſcribe the Meridian M A E R. Now the reaſon you take juſt 60 *deg.* is becauſe that number of degrees taken from the Scale is the Semidiameter of the Circle the Scale was made by: ſo then whatſoever you take from that Circle, and apply to the Scale, it will be the quantity of it in degrees and minutes; or from the Scale if you take any diſtance, and apply it to the Circle, it will be the ſame quantity upon the Circle, that it was upon the Scale.

The Meridian being thus deſcribed, draw the line A R through the Center, which repreſents the Horizon: Croſs that at right Angles, and draw the line E M, which is the Eaſt and Weſt Azimuth.

Then becauſe the Sphere is made for the Latitude of 50 *deg.* take 50 *deg.* from your Scale of Chords, and fix one foot in the Horizon at A, and ſet the other foot upwards to B, (make a prick or mark) which is to ſignifie that the North Pole is elevated or raiſed above the Horizon ſo many degrees as the Latitude is.

Keep the ſame diſtance in your Compaſſes, and go to E with one foot, and let fall the other upon the Meridian on the left hand, which will be at G, and will repreſent that point of the Æqinoctial that cuts the Meridian of that place which is the neareſt point of the Æquinoctial to that Zenith, and is as much below the Zenith, as the Pole is above the Horizon.

Latitude 50 *deg.* 00 *min.* *Declination.*
Northerly 13 *deg.* 15 *min.*



Keep the ſame diſtance, and carry your Compaſſes to the Horizon at R, and let fall the other point to K in the Meridian , which is the South Pole ; for as much as the North Pole is elevated above the North part of the Horizon (at A) ſo much is the South Pole depreſſed below the South part of the Horizon at K.

Continue the ſame diſtance between your Compaſſes, and fix one foot in the Nadir at M, and ſet the other foot upon the Meridian upwards to O, which is the other point of the Æquinoctials interſection in the Meridian oppoſite to the former; and it ſtands to good reaſon, that as much as the Æquinoctial is below the Zenith, ſo much it ought to be above the Nadir: Theſe marks being ſet off, draw the Axis of the World B K, and the Æquinoctial G O. And becauſe (as I ſaid before) the outmoſt bounds of the Suns Declination is 23 *deg.* 30 *min.* (either to the Northwards or Southwards of the Æquinoctial, which bounds are expreſſed by the Tropicks) take 23 *deg.* 30 *min.* from your Scale of Chords, and fix your Compaſſes at O in the Æquinoctial, and ſet it off on both ſides to P and N, carry the ſame diſtance to G, and ſet it off in like manner from G to F and H, then draw F P and H N, which are the Tropicks: alſo draw the Ecliptick from F to N, which will fall through the Center. Always ſet the ſame diſtance from both Poles on both ſides upon the Meridian, and draw D C the Artick, and I L the Antartick Circles. And thus you may project a Sphere by a Plain Scale: The like for any other.

Before I proceed to the Queſtions, it will be neceſſary to give you the meaning of things that will be ſpoke to.

The Meaning of the Terms uſed in the following Work.

THe Latitude of any place is the Diſtance between the Zenith of that place, and the Æquinoctial in degrees and minutes.

The Elevation of the Pole is always equal to it, and is the Poles height above the Horizon in degrees and minutes.

Altitude ſignifies the Height of a thing: If it be meant of a Star, or of the Sun (not being upon the Meridian) it is meant the Diſtance between the Sun or Star and the Horizon.

Meridian Altitude is the Suns height above the Horizon, when he is upon the Meridian of that place, which is at 12 of the Clock; or at any other time when a Star is upon the Meridian either North or South.

The Suns true Amplitude of riſing or ſetting ſignifies the number of degrees and minutes that the Sun riſeth from the Eaſt, or ſets from the Weſt points of the Compaſs in the Horizon, as it is found in the Sphere.

The Suns true Azimuth of riſing or ſetting ſignifies the diſtance (in degrees and minutes) of the Suns riſing or ſetting (in the Horizon) from the North or South points in the Compaſs, as it is found in the Sphere.

There is the true Amplitude of the Suns riſing and ſetting, and the Magnetical Amplitude; the Magnetical Amplitude is the degree of the Compaſs that he is obſerved to riſe or ſet upon, and is Called Magnetical Amplitude from the Load-ſtone: The Magnetical Azimuth is Called ſo for the ſame reaſon, and is the Suns riſing from the South or North.

Longitude is the Eaſting or Weſting between two places in degrees and minutes, if in ſailing.

Departure from the Meridian is the Eaſting or Weſting between two places in miles or leagues.

Latitude, as I have ſaid, is the Diſtance of the Æquinoctial from the Zenith of that place in degrees and minutes, or the Elevation of the Pole; but Difference of Latitude is the Northing or Southing that a Ship makes in any Diſtance run, or between two places, either in degrees, leagues, or miles.

Declination (if it be meant by the Sun, or any Star that is near the Æquinoctial) is the neareſt diſtance between the Sun or Star and the Æquinoctial.

Stars that are nearer the Poles, their Declination are their neareſt Diſtance to the Poles.

The Suns place in the Ecliptick is his neareſt Diſtance from the place where the Suns Parallel of Declination cuts the Ecliptick to the next Æquinoctial point, which is ♈ or ♎.

There be ſeven Planets which I have here inſerted, with their Characters under their Names.

Saturn	*Jupiter*	*Mars*	*Sol*	*Venus*	*Mercury*	*Luna.*
♄	♃	♂	☉	♀	☿	☽

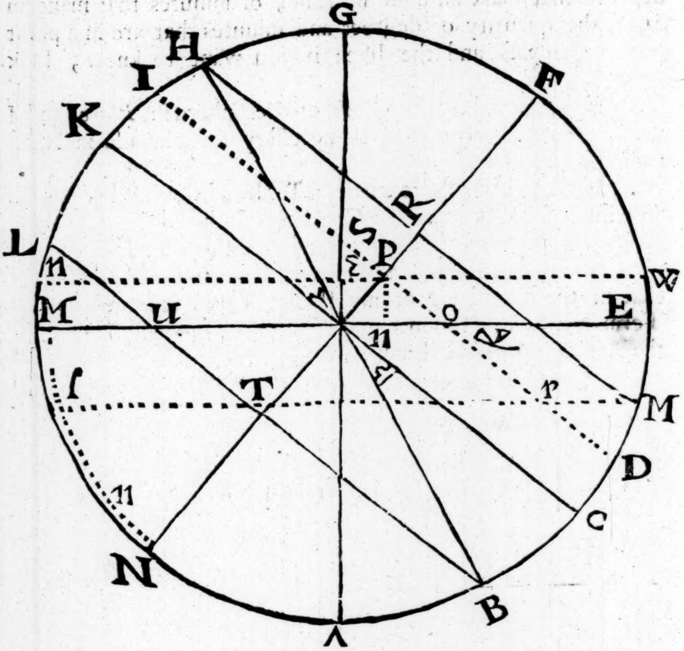
I have noted already in *pag.* 3 of this Book, the quantity of degrees that make an hour in time, of minutes that make an hour, the quantity of degrees and minutes that are in a point of the Compaſs and the like: if you want to know, look there.

I'll now proceed to the Work of the Sphere in *Plano*, and I will handle no more than is neceſſary for our uſe in Navigation.

I had thoughts to have made a Table of the hard Terms of Art uſed (which our vulgar Capacities do not ordinarily comprehend) with their meaning, but then I conſidered what my own Method would be; and ſo I would not trouble my ſelf with that at the Beginning of my Book: There are no intricate Terms uſed, but the meaning of them is commonly ſhewed in the Beginning of the Book.

Latitude and Declination given, to find the things following in the ſeveral Queſtions.

Latitude 50 deg. 00 min. Northerly.
Declination 13 deg. 15 min. Northerly.



Rule. All diſtances of the Sphere that you deſire to know, muſt be extended to the Arch of a great Circle, for by great Circles is the Sphere meaſured.

Que-

QUESTION I.

To find the Meridian Altitude of the Sun.

IN this or any other Sphere, M G E is that part of the Heavens that is viſible, the other half inviſible to us; for it is parted from our ſight by the Earth and Sea, and the furtheſt part of it, which ſeems to mix as it were with the Heavens, we call the Horizon, which is the great Circle M E (for it is a great Circle, though here we are forced to repreſent it by a ſtreight Line) M is the South point of the Horizon: Now the Suns Meridian Altitude is his diſtance between that point and the place he cuts the Meridian that day, which is M I; fix your Compaſſes in M, and extend the other foot to I, and apply it to your Scale of Chords, and as many degrees as you find it there, ſo many degrees is the Sun high when he is upon the Meridian that day, which is the thing required.

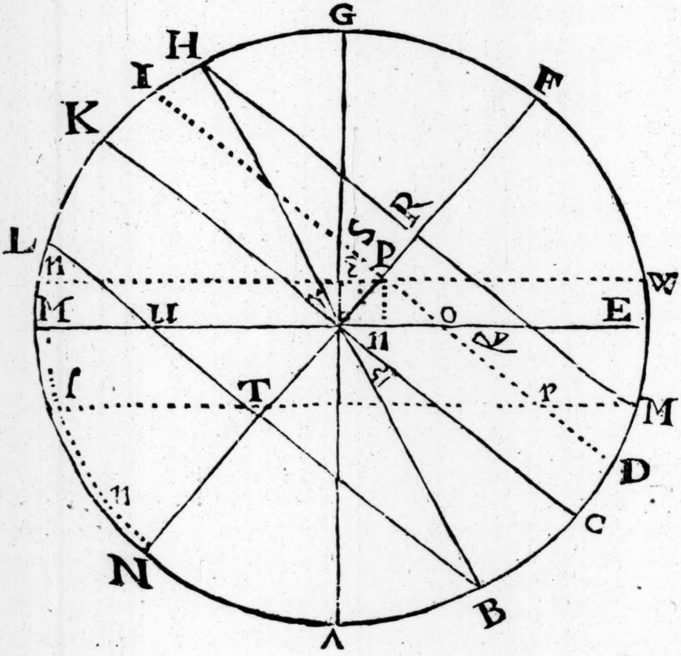
Note that at O the Sun riſeth, at P it is 6 of the Clock, and P I is equal to ♈ K (when it is extended to a great Circle) and both the Sine of 90 *deg.* which is extended to a Chord, muſt be the Chord of as many degrees, which is 6 hours in time. The time between 6 a Clock and 12, which proves that M I is the Meridian Altitude of the Sun: and this meaſuring any Diſtance from the Meridian is called *The firſt Way of Meaſuring.*

QUESTION II.

To find the Suns Amplitnde of Riſing and Setting.

FIx one foot of your Compaſſes in the place of the Suns Riſing, which is O, and extend the other foot to the Center of the Sphere (which is termed the Eaſt point of the Horizon) and this Diſtance apply to your Line of Sines (if you have any) but if you have no line of Sines, extend it to the Chord of the ſame Arch, thus: Fix your Compaſſes with that diſtance, one foot in the Meridian, ſo that the other may juſt ſweep a line that goeth through the Center of the Sphere, then, ſay I, the Arch between that foot of your Compaſſes that ſtands in the Circle, and the place where this line you ſweep cuts the Circle, is the Chord of the thing required., and will be the ſame number of degrees upon the line of Chords, as O R would be upon the line of Sines: and after this manner is the Chord of any diſtance(taken from a line that goeth through the Center of the Sphere) found: and this is called *The ſecond Way of Meaſuring.*

I find that the Sun riſeth 20 *deg.* 53 *min.* to the Northwards of the Eaſt (for ſhe hath North Declination, and the Latitude is Northerly) or ſets ſo much to the Northwards of the Weſt.



QUESTION III.

To find the Suns Azimuth at ſix of the Clock.

THe Suns Azimuth at 6 of the Clock, is the neareſt diſtance between the Sun at 6 of the Clock, and the Eaſt and Weſt Azimuth, which is Pz: Now if you mind it, Pz is taken off from a Circle, which is not ſo great as the Horizon, and yet is parallel to it, as the line nw is parallel to the line ME; and as many degrees as the Sun is from the neareſt part of the Eaſt and Weſt Azimuth in the little Circle, ſo many he is from it (if an Azimuth where drawn) in the great Circle, for Pz is as many degrees in the little Circle, as n♈ is in the great one: Now becauſe your Scale is made by the great Circle, therefore extend the diſtance taken from the leſſer Circle to the meaſure of the greater, which is done thus:

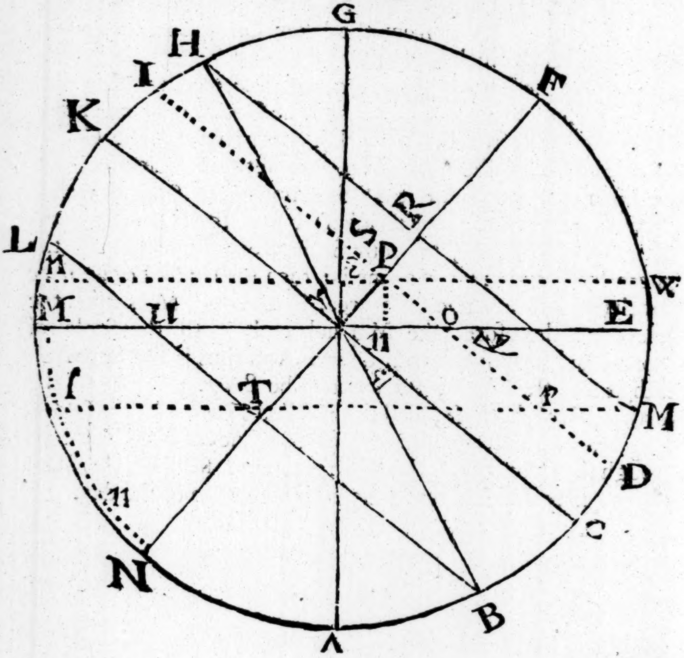
Take half the length of the pricked line which is zw, and fixing one foot of your Compaſſes in the Center of the Sphere, deſcribe an Arch from ſome line that goeth through the Center of the Sphere, as the Arch Mln, then ſet the diſtance zP as a Sine upon that Arch (for it is a Sine upon that Arch as well as o♈ was a Sine upon the Meridian) I find the Sine of it is the Sine of the Arch lM, lay your Scale from the Center of the Sphere by l, and draw the line lq then ſhall qM be the ſame quantity of degrees upon the great Circle, as lM is upon the little one: therefore take Mq and apply it to the Scale of Chords, and it anſwers your deſire. And thus is the Suns Azimuth at 6 of the Clock, Pz found to be 8 *deg.* 36 *min.* to the Northwards of the Eaſt, and this is called *The third way of Meaſuring*, to meaſure any diſtance from a line that doth not go through the Center (which muſt repreſent a ſmall Circle) And thus you may find the Suns Azimuth at any time of the day.

QUESTION IV.

To find the Suns height at ſix of the Clock.

THe Sun is at P at 6 of the Clock: fix one foot of your Compaſſes in P, and extend the other to ſweep the Horizon, which is the ſame as though you let fall the Perpendicular P n, ſet it off by *The ſecond way of Meaſuring*, as was ſhewed in *Queſt.* 2. and apply it to your line of Chords; and the reaſon is, becauſe P n repreſents a part of a great Circle, and ſo is to be underſtood to be of the nature of thoſe lines that go through the Center of the Sphere, for all Azimuths paſs through the Zenith and Nadir, which are two oppoſite points.

I find the Sun is 10 *deg.* 7 *min* high at 6 of the Clock.



QUESTION V.

To find the Suns height being due Eaſt or Weſt.

VV Here the Suns parallel of Declination cuts the Eaſt and Weſt Azimuth, is the place the Sun is in, when he is due Eaſt in the morning, for you ſee he is then over the point of Eaſt in the Horizon, which is ♈ (or the Center) thereſore take the diſtance between that place and the Center (which is S ♈) and apply it to the line of Sines; but if you have no line of Sines, extend it to a Chord after the manner of the ſecond Queſtion, which I call the *The ſecond way of Meaſuring*, for it is the diſtance of a line which goeth through the Center.

I find the Suns height being due Eaſt or Weſt, is 17 *deg.* 25 *m.*

Note, that the ſame height that the Sun is being over the Eaſt point, ſo high he is being over the Weſt point in the afternoon.

QUESTION VI.

To find the Difference of Aſcenſion.

THe Difference of Aſcenſion, is the portion of time that is between the Suns Riſing and ſix of the Clock: If the days be longer than the nights, the Sun riſeth before 6; but if ſhorter, after 6; but whether it be before or after 6 that he riſeth, ſo many hours and minutes as it is from 6, ſo much is the half day or night longer or ſhorter than 6 hours, from whence it is evident, that if the Sun riſeth due Eaſt, he riſeth at 6 of the Clock, and ſo there is no Difference of Aſcenſion, for he is then in the Æquinoctial, which cuts the Horizon in the two oppoſite points of Eaſt and Weſt.

In this Queſtion the Difference of Aſcenſion is O P, and is a diſtance upon a line that goeth not through the Center, therefore take half the length of the parallel I D, and proceed as you did in the third Queſtion, and after you have found it in degrees and minutes, convert it into hours and minutes of time, and ſet it down.

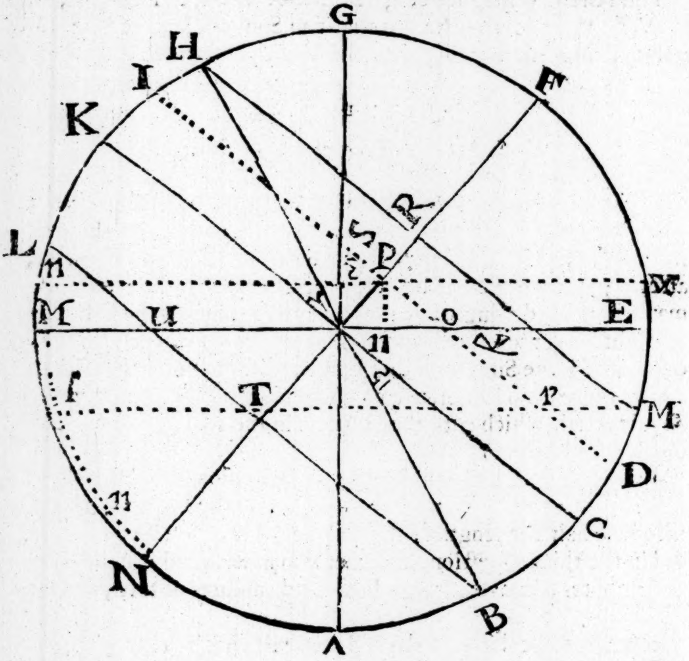
I find it to be here 16 *deg.* 18 *min.* which is 1 hour 5′ $\frac{3}{15}$.

By the Difference of Aſcenſion thus found, you may find the length of the day or night, the hour of Suns Riſing, or the hour of uns Setting.

QUESTION VII.

For the time of the Suns Riſing or Setting in this Example.

I Conſider as much as the Sun riſeth before 6, ſo much he ſets after 6: here he riſeth before 6 of the Clock 1 hour 5′, ſubtract that from 6 hours, and you have the hour of the Suns Riſing 4 *h.* 55′: add it to 6 hours, and you have the time the Sun ſets 7 *h.* 5′. double that, and it is the length of the whole day, which is here 14 *deg.* 10 *min.* Subtract the length of the



day from 24 hours, and it leaves the length of the night 9 *h.* 50′. I omitted the Fractions.

But if the Sun riſeth after 6 of the Clock, and you have a deſire to find theſe things (as he doth when he is South Declination) add the Difference of Aſcenſion to 6 hours, and it gives the time of the Suns Riſing; ſubtract it from 6, and it gives the time of Suns Setting; and that doubled is the length of the whole day. Again, that ſubtracted from 24 hours, is the length of the night.

QUESTION VIII.

To find the hour of the Suns being due Eaſt or Weſt.

THe Sun is due Eaſt (in this Example or any other) when he goeth by the Eaſt point of the Horizon; or Weſt, when he goeth by the Weſt point. In this Example, the Suns parallel of Declination cuts the Eaſt and Weſt Azimuth in S, which is later in the morning than 6 of the Clock, by the diſtance S P: therefore ſee what S P is by *The third way of Meaſuring*, and convert it into time, and add it to 6 hours, it ſhall give the hour of the Suns being due Eaſt.

I find it in this Example to be 6 *h.* 46′.

Subtract this from 12 hours, and it gives the time of the Suns being due Weſt that day: for as many hours and minutes as the Sun is due Eaſt before 12 of the Clock, ſo many hours and minutes muſt it be due Weſt after 12: According to this Example the Sun is due Weſt at 5 of the Clock 14 *min.*

If the Sun hath South Declination, he paſſeth the point of Eaſt before he riſeth, and is ſet as long before he comes to the point of Weſt, (provided the Latitude be Northerly, as this is) but if the Latitude and Declination be both one way, the Sun is always up before he cometh to the point of Eaſt: and the work is as I have ſhewed.

QUESTION IX.

To find the time of Day breaking, and Twilight ending.

IT is an antient Obſervation and concluded Opinion, That the Sun makes ſome ſhew of Day when he is 17 degrees under the Horizon; therefore take 17 *deg.* from your Scale of Chords and ſet it from both ends of the Horizon downwards, and draw the line T r, then fix your Compaſſes in r (the place where the Suns parallel of Declination interſects that line) and extend them to 6 of the Clock; ſet it off by *The third way of Meaſuring*, and convert it into time: Subtract that from 6 of the Clock, and it gives the time of Day breaking.

I find in this Example Day breaks at 3 of the Clock 6 *min.* $\frac{12}{15}$.

Add it to 6 hours, and it gives the time of Twilight ending 8 of the Clock; 53 $\frac{14}{15}$.

It may happen ſo ſometimes, that it may be paſt 6 of the Clock before the Day breaks, in ſuch a caſe you muſt add (in the morning) for break of Day, and ſubtract for Night from 6 hours, which is the contrary: Theſe things your own Reaſon will give you, after you are uſed to it, which makes me forbear to give any more reaſons of it.

QUESTION X.

To find the Continuance of Twilight.

THe Continuance of Twilight is the time between the Day breaking and Sun riſing, which is r o; take it off by the *Third way of Meaſuring*, and convert it into time. I find it to be 1 *hour* 48 *min.*

QUESTION XI.

To find the Length of the longeſt Day in that Latitude.

WHen the Sun is neareſt the Zenith(in any Latitude)that day muſt be the longeſt: now in places near the Æquinoctial, as between the Tropicks, there is but little difference all the year long; but in places nearer the Poles, there is more.

The Sun is neareſt the Zenith in this Latitude, when he is in the Tropick of Cancer, ſo that then muſt be the longeſt Day. Imagine the Tripick of Cancer to be the parallel of the Suns Declination (as indeed it is that day) take the diſtance between Y and R, which is between Suns Riſing and 6 of the Clock that day, and ſet it off by the *Third way of Meaſuring*, the number of degrees and minutes convert into time, and add it to 6 hours, which makes the length of the Forenoon, and that doubled is the length of the whole day (as in *Queſt.* 7.) which is equal to the longeſt Night in that Latitude.

I find it here to be 16 hours 10 minutes.

Subtract the length of this longeſt day from 24 *h.* 00 *min.*

And it leaves the length of the ſhorteſt night 7 *h.* 50 *min.*

Equal to which is the length of the ſhorteſt day 7 *h.* 50 *min.*

But you may meaſure the length of the ſhorteſt day, and ſubtract that from 24 hours, and it will be the length of the longeſt night, which is equal to the longeſt day.

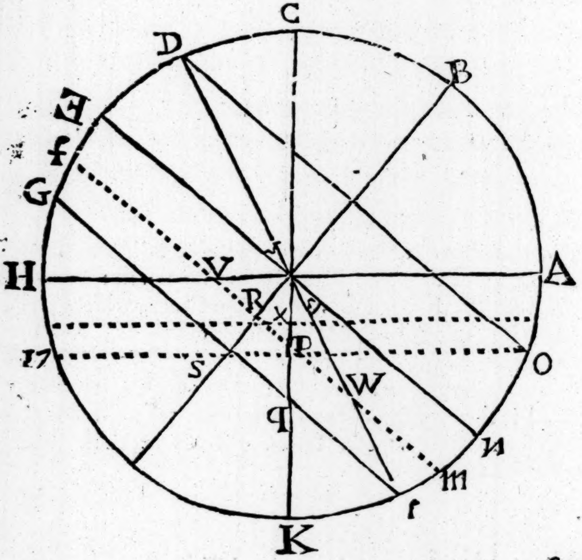
Now the ſhorteſt day is when the Sun is in the Tropick of Capricorn, for then it is lateſt before he riſeth: Now to meaſure it, take the diſtance from 6 of the Clock, which is T, and the Suns Riſing which is U, and ſet it off by the *Third way of Meaſuring*, convert the degrees into time, and ſubtract that time from 6 hours, it leaves the length of the Forenoon, which doubled is the length of the ſhorteſt day; (as in *Queſt.* 7.) I have ſpoke to that purpoſe. I need ſay no more, that 7th. Queſtion is light ſufficient.

I might do an Example of what is before done, in a South Latitude, but Reaſon gives, that the ſame which the South Pole or Southern parts of the Heavens are depreſt in a Northern Latitude, the ſame will the Northern parts of the Heavens be depreſt in a Latitude as far Southerly, ſo that there will be no difference in the work at all: And indeed my deſire to be brief, makes me omit things that I think may be underſtood without treating of them.

I'll only touch upon an Example in a Sphere which hath South Declination.

Latitude Northerly 50 deg. 00 min. *Declination* 13 deg. 15 min. *Southerly*.

THe Meridian Altitude of the Sun is his greateſt height for that day H f, meaſured as before. The Suns Amplitude of Riſing and Setting is V ♈, it is meaſured as before: But whereas before it was to the Northwards of the Eaſt, now its to the



Southwards; foraſmuch as A is the North part of the Horizon, ♈ the Eaſt point of the Horizon (A ♈ being 8 points or 90 *deg.*) and ſo H is the South point: Now you ſee V is between the Eaſt ♈, and the South H.

Alſo, if you ſubtract this Amplitude V ♈ from ♈ H 90 *deg.* the remainder is the Suns Azimuth from the South V H, or if you add V ♈ to ♈ A (90 *deg.*) it is V A the Suns Azimuth of riſing from the North; foraſmuch as V A is as much above 90 *deg.* as V. H wants of it: The ſame is to be underſtood in any Sphere, that the Amplitude and Azimuth of the Sun are Complements one of an other, to 90 *deg.* in that Quarter.

When the Suns Declination is Southerly (in any Northern Latitude) the days are not ſo long as the nights, ſo that the Sun cannot be up at 6 of the Clock, which is at R; therefore the Suns Azimuth at 6 of the Clock is of no uſe.

Neither is he up, when he paſſeth the Eaſt point of the Horizon, which is at P, ſo that you cannot take his height; but you may meaſure how far he is under the Horizon at either of thoſe times, or you may find his true Azimuth at 6, which is of no value to us that are Seamen, becauſe we cannot have a Magnetical Azimuth; they are meaſured as before.

The Difference of Aſcenſion is here after 6 of the Clock, as much as it was before 6, in the laſt Example: And the reaſon is, becauſe the Latitude is the ſame, and the Declination of the Sun is juſt as far Southerly, as before it was Northerly, ſo that the Sun will now be juſt as long before he riſeth after 6, as before he roſe ſooner: it is V R, take it off by the third way of Meaſuring, as you did before, and ſet it down; I find it to be 1 hour 5 *min.* $\frac{2}{15}$, it ſerves for the ſame uſes that it did in the other Example.

For the length of the day, ſubtract the Difference of Aſcenſion V R, from 6 hours, which is R f, and the remainder is f V, the length of the Forenoon, which doubled is the length of the whole day; that ſubtracted from 24 hours is the length of the night.

For the hour of the Suns being due Eaſt, it is P R, which is from the place where the Sun cuts the Eaſt and Weſt Azimuth to 6 of the Clock, and ſet it off by the third way of Meaſuring, convert your degrees and minutes into time, and ſubtract that time from 6 hours, and it gives the due time of the Morning that the Sun cuts the Eaſt point of the Compaſs; the reaſon why you ſubtract is, becauſe the Sun is due Eaſt ſo long before 6 of the Clock.

Subtract the hour of the Suns being due Eaſt from 12 hours, and it will give the true time of the Suns being due Weſt.

For the time of day breaking, draw the line 17 ☉, parallel to the Horizon, and 17 *deg.* under it, as was ſhewed before, and meaſure from P to R, that is, from the place where the Suns Parallel of Declination cuts that Circle of 17 *deg.* (under the Horizon) to 6 of the Clock, convert it into time, and ſubtract it from 6 of the Clock, and it leaves the time of Day breaking, namely, the time in the morning that the Sun is in P; you ſubtract, becauſe the day breaks ſo long before 6 of the Clock: If it where ſo that the Sun were in the Tropick of *Capricorn*, you muſt take the Diſtance S q. You ſee the Sun is paſt the hour of 6 before it is break of day; now in this caſe you muſt add, whereas before you ſubtracted.

For the continuance of Twilight, it is meaſured as before, from the place, where the Parallel of the Suns Declination cuts the Circle of 17 *deg.* to the place where it cuts the Horizon; convert it into time, and ſet it down. In this Example it is P V.

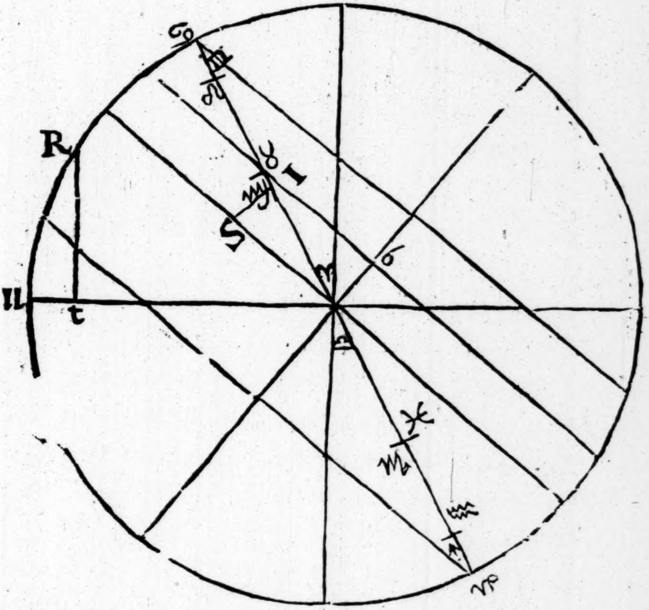
What I have not mentioned here, I have given ſufficient inſtructions about in the other Example before this.

Latitude 51 deg. 30 min. *Northerly, Declination* 11 deg. 10 min. *Northerly, I demand the Suns place and right Aſcenſion.*

BEfore we can find the Suns place in the Ecliptick, you are to conſider that the Ecliptick is divided into 12 equal parts, by the 12 Signs; ſix of theſe Signs divide that half of the Ecliptick, which is to the Northwards of the Æquinoctial, and are called Northern Signs; and the other 6 divide the half that is to the Southwaads of the Æquinoctial, and are called Southern Signs, as I have ſet them down in this Book before, with their Names and Months to their Characters, and have ſet the

Northern Signs by themſelves, and the Southern Signs by themſelves.

It is plain then that theſe Signs muſt be of an equal Diſtance one from the other round about; and becauſe 12 times 30 is 360, the Signs muſt ſtand 30 *deg*. aſunder, and that will juſt do it: Now in this plain Body, half the Ecliptick is repreſented by a ſtreight line that goes through the Center of the Sphere. The line of Signs is taken off, ſo that 90 *deg*. is but ♈ ♋; therefore by a line of Sines you may take firſt 30 *deg*. and fix one foot of your Compaſſes in ♈ (the Center) and with the other deſcribe ♉ ♓, and their oppoſite Signs ♏ ♍; then take 60 degrees for ♊ ♒, and their oppoſite: Then take 90 *deg*. which



reach to the Circumference ♋♑, which is (from the Center) thus ſet off by a line of Sines; but if you have none but a line of Chords, you muſt take the Chord of 30 from your Scale firſt, and leſſen it to a Sine thus, Fix one foot of your Compaſſes in the Meridian where the other foot (with that Diſtance) may ſweep a line that goeth through the Center, as R t; keep your Foot in R, and extend your Compaſſes to U, and ſo you have R U the Chord of the Sine R t, apply it to your line of Chords, and you have your deſire.

This plain Superficies can ſhew but one part of the Globous Body, but you muſt know it is round, which makes the Ecliptick to be divided; on both ſides from ♈ to ♋ is 90 *deg.* from ♋ to ♎ is 90 *deg.* from ♎ to ♑ is 90 *deg.* and from ♑ to ♈ is 90 *deg.* every one of theſe quarters containing 3 Signs.

The Ecliptick being thus divided into Signs; we may find the Suns place, and right Aſcenſion.

THe Suns place in the Ecliptick is the neareſt Diſtance between the next Æquinoctial point, and the Sun in the Ecliptick, (by Æquinoctial points is meant ♈ and ♎, the two points of interſection that the Æquinoctial and the Ecliptick make) Now, in this caſe, the Sun muſt be neareſt the Equinoctial point at ♈, becauſe the Month is belonging to a Sign nearer ♈ than ♎.

Therefore, fix your Compaſſes in the point of ♈, and extend the other foot to the Sun in the Ecliptick, which is I, and apply it to the line of Sines; or if you have no line of Sines, convert it to a Chord (by the ſecond way of Meaſuring) and as many degrees as it is, ſo far is the Sun diſtant from the neareſt Æquinoctial point; if it exceed 30 *deg.* the Sun muſt be in that degree of ♉ that is above 30 *deg.* if it exceed 60 *deg.* the Sun muſt be in that degree of ♊ above 60; but here I find it in leſs than 30, namely, 29 *deg.* 3 *min.* therefore I conclude the Sun is in 20 *deg.* 3 *min.* of ♈.

But ſuppoſe it were time of year that the Sun were returning from the Tropick towards the Æquinoctial, and were the ſame Declination, then would the Suns place be the ſame from entring into ♎, that it now is in ♈, namely, in 57 *min.* of ♍, which wants 29 *deg.* 3 *min.* of entring into ♎. Thus much for the Suns place.

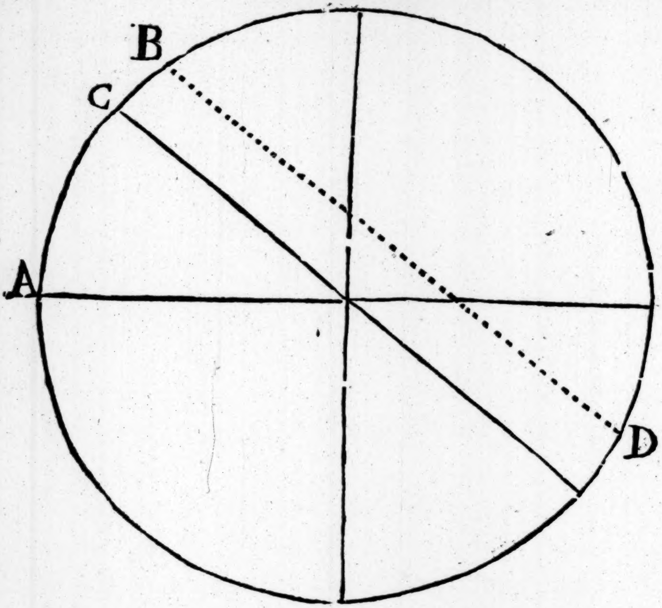
The Suns right Aſcenſion is meaſured from the place where the Suns parallel of Declination cuts the Ecliptick to 6 of the Clock, which is I 6; ſet it off by the third way of Meaſuring to extend it to a Great Circle: for the Sine of I 6 is equal to the Sine of S ♈; when you have meaſured it, convert it into time, and ſet it down; I find it to be 1 hour 44 *min.*

The Meridian Altitude of the Sun being given, and the Latitude, to find the Suns Declination, as alſo all the other things before found.

Latitude 51 deg. *Northerly, Meridian Altitude* 52 deg. 30 min. *I demand the Suns Declination, or any other thing that I found before.*

FOR the doing of this, project your Sphere (as before was ſhewed) that done, I conſider the Meridian Altitude of the Sun is given to be 52 *deg.* 30 *min.* I will take 52 *deg.* 30 *min.* from the Scale of Chords, and fix one foot of my Compaſſes in the South point of the Horizon at A, and extend the other foot upwards upon the Meridian, which falls at B; then I conclude the Sun is upon the Meridian, in the point B: Take the Diſtance between B and the Æquinoctial, which is B C, and apply it to the Scale of Chords, and ſo much as it is, ſo much is the Declination of the Sun; and you ſee it is Northerly, for the Sun is to the Northwards of the Æquinoctial. If you have a deſire to find any thing elſe in this Sphere, draw the Parallel of the Suns Declination (thus found) and work with it as before in other Examples; alſo draw the Ecliptick and Tropick.

Many



Many other things might be done, but for Brevities ſake I omit them, judging this to be as much as we have occaſion for in Navigation, which is the thing I aim at. If I have committed a fault in being too tedious in theſe things, pardon me, and remember it was my Beginnings; riper years (which may bring more ability, it is probable) will bring forth ſomething more new and admirable. Be charitable.

Terms of Art uſed in Navigation.

L*Atitude* (as I have cited before) is the Diſtance between the Æquinoctial and the Zenith; what is meant by *Longitude* and Difference of *Latitude*, I have ſhewed before; alſo the difference between *Longitude* and *Departure* from the *Meridian*, in this Book before.

Now in every Diſtance that is ſailed upon any Courſe that makes an Angle from the Meridian, either of North or South, or the Parallels of Eaſt and Weſt, that is to ſay, any Diſtance that is ſailed upon a point that is between thoſe Courſes; we have theſe things conſiderable, namely, The Diſtance run, (which muſt be the longeſt ſide) the Difference of *Latitude*, and Difference of *Longitude*, or Departure from the Meridian, and the Courſe; the Courſe is the Point of the Compaſs or Rumb you ſteer on.

A *Dead Reckoning* is when a man cannot obſerve, but is forced to judge of the Courſe and Diſtance, to find the Difference of *Latitude* and *Departure*.

A *Reckoning* is an Account of the Difference of *Latitude* and *Departure* from the Meridian, that is made in the time a Ship hath been out.

Read *Tan.* for Tangent, *Sine com.* for Sine Complement, *Tan. com.* for Tangent Complement, *comp arith.* for Complement Arithmetical.

PROPOSITIONS of SAILING BY THE PLAIN SCALE.

Difference of Latitude and Courſe given, to find the Diſtance run, and the Departure from the Meridian.

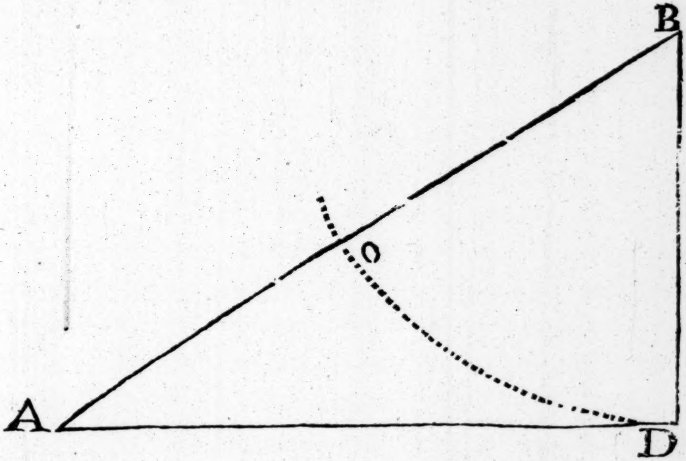
QUESTION I.

Admit I ſet from the Lizard, *lying in the Latitude of* 50 deg. *and ſail* S W b W, *till I alter my Latitude* 1 *degree or* 60 *miles: I demand my Diſtance run, and Departure from the Meridian.*

IN this Queſtion we have the Courſe 5 points from the Meridian towards the Weſt, which is 5 times 11 *deg.* 15 *min.* or 56 *deg.* 15 *min.* for 5 times 15 *min.* is 75 *min.* or 1 *deg.* 15 *min.* and 5 times 11 *deg.* is 55 *deg.* to which add the 1 *deg.* and 15 *min.* and the whole is 56 *deg.* 15 *min.*

To protract this Queſtion or any other of this nature, I wiſh you to obſerve the end of your Book, that lies from you to be the North part of your Book, then that to the right hand will be the Eaſt part, that to the left hand the Weſt, and that right to you the South part: The Reaſon why I wiſh you to obſerve this Method, is, that ſo in any Travis you may ſet every Angle the right way, which muſt be obſerved then, and is good to be always uſed.

Firſt draw the South line B D, let B be the *Lizard*, then ſet off from B 60 miles upon the South line (taking it from a Scale of equal parts) which is your Southing B D. Foraſmuch then as B D is the Difference of Latitude that I have made ſince I ſet from B, D muſt ſtand in the parallel that I am in; and becauſe I have ſailed to the Weſtwards of the Meridian D B, I



will raiſe a Perpendicular which is a Weſt line from D, and draw it at length, which is D A. This done, take an Arch of 60 *deg.* from your Scale of Chords, and (making the place you ſet from, the Center) deſcribe the Arch D O, and upon it ſet off 56 *deg.* 15 *min.* which is D O 5 points; then by B and O draw the ſine B O, till it interſect the line A D, which it doth in A: Now Foraſmuch as D A is parallel in the Latitude the Ship was in after her ſailing, and D B A an Angle of the Courſe from the Meridian, B A muſt interſect the Weſt line in the place where the Ship is; then the Diſtance run is B A, and the Departure from the Meridian is D A, which take off ſeverally, and apply to the Scale of equal parts, and ſet down what they come to: Here I find them as followeth:

The Diſtance runs is B A 108 *miles*.
The Departure from the Meridian is 090 *miles*.

But beſides this Geometrical way of reſolving Triangles, there is an exacter way by the Tables of Sines, Tangents, and Logarithms, which is done thus,

A General Rule.

Note that in all right lined Triangles the Sine of every Angle is proportional to its oppoſite ſide, or every ſide is proportional to the Sine of its oppoſite Angle.

The greateſt ſide will have the greateſt Angle oppoſite to it, the laſt ſide will have the leaſt Angle oppoſite to it: As here in this Queſtion, A B is the longeſt ſide, and oppoſite to it is the right Angle B D A, which is the greateſt Angle, A D is the next, and hath A B D to it, D B is the leaſt ſide, and hath D A B for its oppoſite Angle, which is the leaſt Angle. Now as the Sine of A is to B D, ſo is the Sine of D to A B, or the Sine of B to A D, and the contrary.

To find the Diſtance run.

As Sine com. B 56 deg. 15 min. *comp. arith.* 0,25526
To B D 60 min. 1,77815
So is Radius or Sine D 90 deg.
To A B 108 *miles* 2,03341

If Radius be not in the firſt place, you muſt take the Complement arithmetical of the firſt number, as here I have done; but if Radius be in the firſt place, take no Complement arithmetical at all: The Complement arithmetical of a number is what every ſingle figure wants of 9, take them in their due places, as here the Sine in the Tables anſwering to A 33 *deg.* 45 *min.* (which is the Sine Complement of B 56 *deg.* 15 *min.*) is 9,74473, whereas I have ſet it down 0,25526, now if you compare them, the number that I have taken is what the figures in the other want of 9, as 9 wants 0, and 7 wants 2, and 4 wants 5, and ſo forward; after the Complement arithmetical of the firſt number is taken, take the others as they be in the Tables, and add them together, caſting away Radius always, and look for what comes out, either in the Sines, Tangents, or Logarithms, according as the order requires into which the proportion runs. You ſee here I took no notice of Radius, which is a caſting of him away: in like manner if the things added up come to above Radius, always caſt Radius away, and ſet down what is above Radius; as here the laſt came out to be 11, and I caſt away the 10, and ſet down 1.

For the Departure from the Meridian.

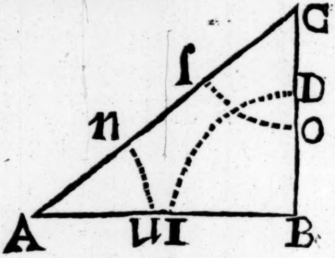
As Sine comp. B 56 deg. 15 min.	*comp. arith.*	0,25526
Is to B D 60 *miles*		1,77815
So is Sine B 56 deg. 15 mim.		9,91984
To A D *almoſt* 90 *miles*		1,95325

But I have been often asked by them that I have learned, why I contradict the Rule, which ſaith, that the Sine of every Angle is proportional to its oppoſite ſide or the contrary. Now here you ſay, as Sine compl. B to B D, either you are falſe, or elſe the Sine comp. of B is the Sine of A, for A is the Angle oppoſite to B D, whoſe Sine the Rule orders you to take.

I anſwer that A is the Complement of B, for this is certain, that the three Angles of any right lined Triangle conſiſts of a Semicircle or 180 *deg.* and neither more nor leſs: Now if it be ſo, B A D and D B A muſt together be but 90 *deg.* becauſe B D A is 90 *deg.* it ſelf; then if B is 56 *deg.* 15 *min.* the Sine comp. of it muſt be the Sine of 33 *deg.* 45 *min.* which is the Sine of A, oppoſite to B D.

But you will ask how you ſhould know that the three Angles of a right lined Triangle is but 180 *deg.* Pray mind this Demonſtration.

In the right angled Triangle A B C, the Angle that is contained between the Perpendicular and the Baſe (which is A B and B C) is always a right Angle, or 90 *deg.* 0 *min.* or 8 points



of the Compaſs, which is B: Now I ſay, that the other two A and C are juſt 90 *deg.* together, which makes all three twice 90 *deg.* For your better ſatisfaction meaſuring the Angles thus:

Set your Compaſs at any convenient diſtance, and from every angular point as a Center, deſcribe an Arch, as I O, U n, and ſ D; now I D is an Arch of 90 *deg.* 0 *min.* becauſe it is included between two ſides that are perpendicular one to the other; then U n and ſ O together are equal to I D; meaſure them, and ſet them upon the Arch I D, and they will be equal to it. From hence then it is evident, that ſ O and U n, or the two Angles beſide the right Angle of any right angled Triangle, are Complements one of the other to 90 *deg.* or that the three Angles of any right lined Triangle are 180 *deg.* or two right Angles or a Semicircle.

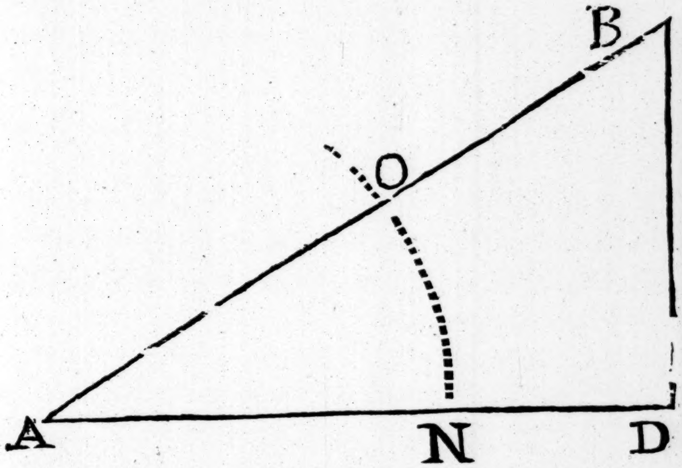
Courſe and Difference of Longitude in miles given, to find the Difference of Latitude and Diſtance.

QUESTION II.

Admit I ſet from the Lizard, *lying in the Latitude of* 50 deg. *and ſail* S W b W, *till I depart from my Meridian* 90 *miles: I demand my Difference of Latitude and Diſtance run.*

LEt A repreſent the place your Ship is in, after ſhe hath ſailed; from whence draw the Eaſt line A D, then take 90 miles from your Scale of equal parts, and ſet off upon that line from A, which falls at D.

From D raiſe a Perpendicular or North line which is D B: Now, foraſmuch as it is ſaid, that the Ship ſailed S W b W, which is 5 points from the South towards the Weſt backwards, that is N E b E, 5 points from the North towards the Eaſt, or 3 points from the Eaſt towards the North. I will take an Arch of 60 *deg.* from my Scale of Chords, and from A as a Center I'll deſcribe the Arch O N, and from N I'll ſet 3 points upon that Arch which reacheth to O, and by A and O, I will draw the line A B till it cut the North and South line in B; then is B D the Difference of Latitude, and A B the Diſtance run, which meaſure and ſet down.



The Difference of Latitude is 60 miles.
The Diſtance run is 108 miles.

By the Tables. *For the Diſtance run.*

As Sine comp. A 33 deg. 45 min.	*comp. arith.*	0,08015
To A D 90 *miles*		1,95424
So is Radius		
To A B *almoſt* 108 *miles*		2,03439

For the Difference of Latitude.

As Radius to the Diſtance run 108 A B	2,03342
So is Sine comp. the Courſe 56 deg. 15 min. B	9,74473
To the Difference of Latitude D B 60 *miles*	1,77815

Here to find the Diſtance run, I made uſe of the things that were given me, but for brevities ſake that I might ſhew the taking of a Complement arithmetical, I uſed Radius with the Diſtance before found, to find the Difference of Latitude.

But if you would not do ſo, then the things given will do as well, and the Proportion holds thus.

As Sine comp. A (*which is Sine* B) *is to* A D *ſo is Sine* A *to* B D.

Courſe and Diſtance run given, to find the Difference of Latitude and Departure from the Meridian.

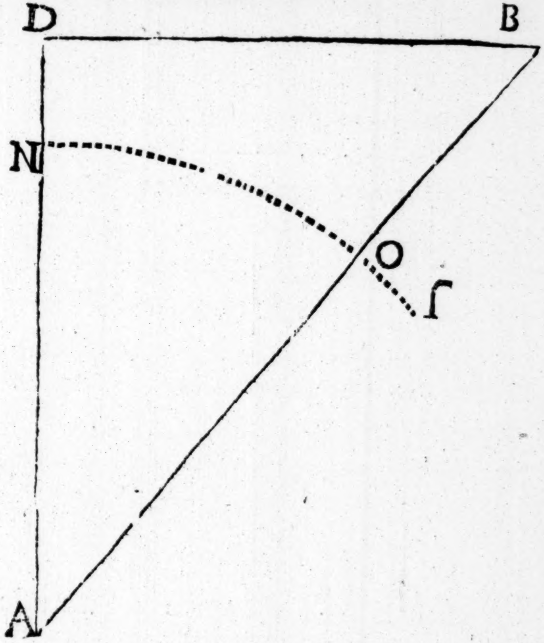
QUESTION III.

Admit I ſet from the Latitude of 50 deg. 0 min. *and ſail* N E b N 108 *miles: I demand the Difference of Latitude and Departure from the Meridian.*

LEt A D be a Meridian line, A the Latitude of the *Lizard*, D A B the Angle of the Courſe, ſet off by the Arch of 60 *deg.* N O ſ (N O being 3 points) A B a line drawn from the Latitude of the *Lizard* A by O, and the Diſtance that the Ship hath ſailed ſet upon it, and no more, namely, 108 miles; then I conclude that the Ship is at B, from B let fall the Perpendicular B D, which cuts the Meridian in D, and leaves D A for the Difference of Latitude, and is it ſelf the Departure from the Meridian; meaſure them as you have been ſhewed before, and apply them.

Difference of Latitude D A 90 miles.
Departure D B 60 miles.

By



By Proportion.

I have two things given beſides the right Angle, namely, the ſide A B 108 miles, and the Angle B A D 33 *deg.* 45 *min.* therefore to find the Difference of Latitude A D.

As Radius	
To the Diſtance run 108 *miles* B A	2,03342
So is Sine comp. A 33 deg. 45 min.	9,91984
To A D *the Difference of Latitude* 90 *miles*	1,95326

For the Departure from the Meridian.

As Radius	
To the Diſtance run 108 *miles* B A	2,03342
So is Sine A 33 deg. 45 min.	9,74473
To D B *the Departure from the Meridian* 60 *miles*	1,77815

In your putting things in proportion, follow theſe directions; always put the required thing in the laſt place, and the things you know, make uſe of, and put in proportion to find the things you know not.

If it be a Side you are to find, begin with an Angle; if it be an Angle, begin with a Side

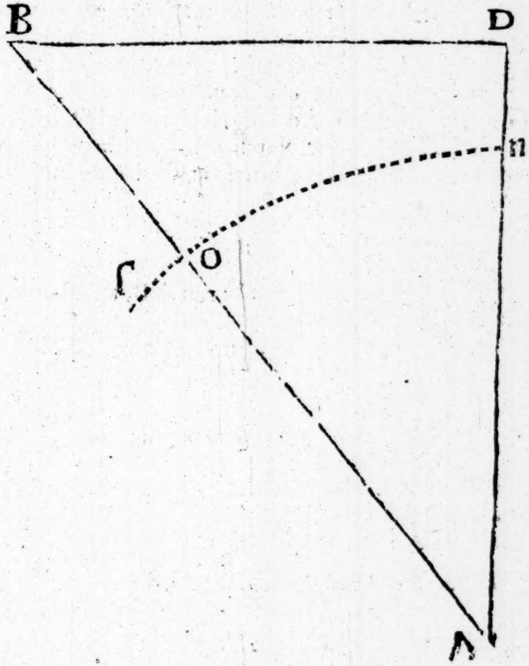
Here it was a Side that was to be found (in both theſe Proportions) you ſee I began with an Angle, that I knew which was Radius; but you may ask why I did not begin with the given Angle at A or B as well, I anſwer, becauſe neither of the things oppoſite to them were given, ſo that I could not proceed, if I had.

Diſtance run and Difference of Latitude given, to find the Courſe aud Departure from the Meridian.

QUESTION IV.

Admit I ſet from the Latitude of the Lizard 50 deg. 0 min. *and ſail upon ſome point between the North and the Weſt* 108 *miles, till I alter my Latitude* 1 deg. 30 min. *or* 90 *miles: I demand the Departure from the Meridian and Courſe.*

FIrſt draw the North and South line A D at length: Let A be the place in the Latitude of 50 *deg.* take the Difference of Latitude 90 miles from the Scale of equal parts, and ſet it off North from A, which falls at D: Now becauſe D is as far to the Northwards of A, as the Difference of Latitude which you made from A is, therefore if you draw the Weſt line D B at length, it muſt cut through the place where the Ship is: I look upon the Queſtion again, and I find that the Diſtance run ſince the Ship ſet out is 108 miles; take 108 miles from the Scale of equal parts; and becauſe the Ship ſet from A,



fix one foot in A, and where the other foot interſects, or cuts the parallel that the Ship is in D B, there the Ship muſt be; and thus if her Difference of Latitude be A D 90, and her Diſtance run A B 108 miles, B D muſt be the Weſting, and n O the meaſure of the Courſe from the Meridian of Northweſterly, or the Angle D A B.

Take the Difference of Longitude D B, and apply it to your Scale as before.

Take O N the meaſure of the Angle of the Courſe, and apply it to the Scale of Chords (if you are minded to ſee her Courſe from the Meridian in degrees and minutes) to the points of the Compaſs, if you deſire to know it in points.

Note that A is the Center of the Arch O n 60 *deg.* It is plain, that if an Arch of 60 *deg.* deſcribed, and any number of points or degrees that is ſet upon it, be an Angle of thoſe points ſet down (as it hath been in every Example before) then whatſoever you take from an Arch of 60 *deg.* is fit to apply to the Scale.

I find the Courſe to be North 33 *deg.* 45 *min.* Weſterly, or N W b N. I find the Departure from the Meridian to be 60 *mil.*

By the Tables.

Here I have given the Diſtance run A B, and the right Angle oppoſite to it, and the Difference of Latitude A D, whereby I may find the Angle oppoſite to it B, or the Complement of it, which is A, the Angle of the Courſe.

For the Courſe.

As the Diſtance run A B 108 *miles comp. arith.*	7,966576
Is to Radius	
So is the Difference of Latitude A D 90 *miles*	1,954242
To the Courſe or Rumb Sine comp. B 33 d. 33 m.	9,920818

For the Departure.

As Radius	
To the Diſtance run A B 108 *miles*	2,0334237
So is Sine the Courſe A 33 deg. 33 min.	9,9424616
To D B *the Diff. of Longi. here found to be* 60 *miles*	1,7758853

You may ask the reaſon why the Courſe is not 33 *deg.* 45 *min.* as it was firſt given to be: I anſwer, becauſe of the part of an unite, that the Difference of Latitude was ſet down more than it ſhould be; for if you obſerve, I ſaid it was almoſt 90 miles, when I found it before: Now the error is not worth minding in Sailing, for the Difference that the Fraction cauſeth is but 12 *min.* of a degree of a point of the Compaſs, which is no more than the 56th. part of a point.

If you mind, I have worked the Courſe thus found, and it doth not alter the Difference of Longitude or Departure (which ſhould be 60 miles, if I had worked to the leaſt Fraction) for the Logarithm here is neareſt to the Logarithm of 60 in the Tables: Indeed I worked on purpoſe thus, becauſe thoſe that I have taught, when they could not find it come out right as the other was, could not tell where the fault lay; now this will direct them to know that ſome part of a unite miſſing in the finding of the Sides, may make ſome minutes Difference in the Courſe: But now, here in the following Examples we will work to a Fraction, namely, to the 10th. or 100th. part of a unite, (in the ſides) to ſhew how it is done; though in Sailing if you work to half an unite, it is near enough, or for any ordinary uſes (and that the Tables give) and moſt commonly to leſs.

Departure from the Meridian and Diſtance run given, to find the Courſe and Difference of Latitude.

QUESTION V.

Admit the Departure from the Meridian were the ſame that the Difference of Latitude was in the firſt Queſtion 60 *miles, the Diſtance run alſo* 108 *miles: I demand the Courſe and Difference of Latitude, let the Latitude you ſet from be* 50 deg.

HEre the Courſe from the Meridian will be the Complement of the Courſe there, and the Difference of Latitude will be the Difference of Longitude, or Departure from the Meridian there.

But inſtead of taking the Logarithm anſwering to the number here, take the Logarithm anſwering to ten times the number, and ſo you ſhall always have your ſides come out to the tenth part of a unite; I ſay it will come out in tenths, for you muſt divide by 10, to bring it into miles after it is done.

Now inſtead of multiplying your given ſides by 10, do but ſet a Cipher more to the number and it is done, as now for 60 ſet down 600, which is ten times 60; for 108 ſet down 1080, which is ten times 108; and thus for any number that will be comprehended in the Radius of the Tables..

Proportion for the Courſe

As Diſtance run given B A 1080 *tenths comp. arith.*	6,9665762
Is to Radius,	
So is the Departure from the Meridian 600 *tenths* D B	2,7781512
To the Sine of the Courſe A 33 deg. 45 min.	9,7447274

For the Difference of Latitude.

As Radius	
To the Diſtance run 1080 *tenths* B A	3,0334327
So is the Sine comp. of A 33 deg. 45 m.	9,9198464
To the Diff. of Latitude in tenths D A 898 *tenths*	2,9533708

Divide theſe tens by 10, and it gives the miles contained in the ſide D A the Difference of Latitude, which is 89 miles 8 tenths of a mile, whereas before it was 90 miles, whis is 2 tenths of a mile more: Now when you have the ſides thus found in tenths or Centiſms; work for the Angles, and you will find them to come out roundly alike: But if you deſire more exactneſs, work then in Centiſms, provided, that the numbers in Centiſms do not out-run the Tables.

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A Centiſm is the hundredth part of an unite, or of any thing; and if I would put the number 60 into Centiſms, I will ſet two Ciphers behind it, and it is the ſame as before; I multiplied 60 by 100, for it is 6000, the like is to be underſtood of any other number.

I would work to the neareſt Fraction for the Angles here, but I conceive it to be no way beneficial, and therefore I'll refer it to the work of the Sphere, where it is of much more uſe; this finds the Angles to a minute, which is near enough.

It is like that ſome will be ſo curious, that this way of finding things to the tenth or hundredth part of unit will not ſuffice them, but they would have the real number anſwering to the Logarithm to the 1000th. part of a unite; becauſe I find it of no real conſideration or uſe in Navigation, I omit that here, and deſire ſuch to look in Book 1. Page 11. of my Fathers *Trigonometry*, and there it is plainly ſhewed.

By the Plain Scale.

This Queſtion differs nothing from the other in its operation, only as you work in the other from a North and South line, here you work from an Eaſt and Weſt line; The work is this.

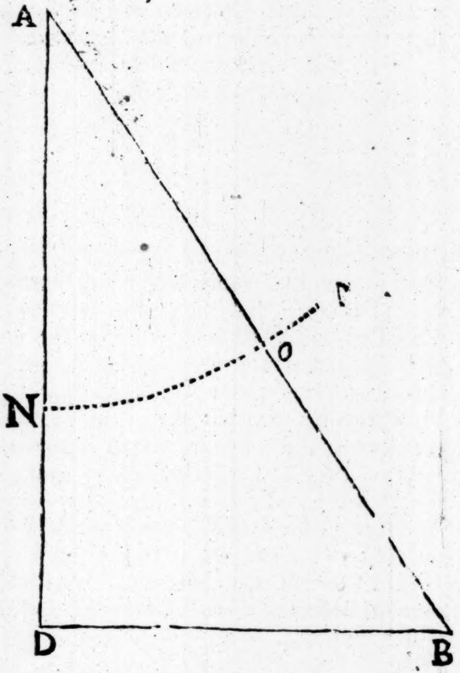
Firſt, draw an Eaſt and Weſt line, and from the weſt end of it, ſet off your Departure from the Meridian, which is from D to B 60 miles; from D raiſe the Perpendicular D A (which is a North and South line) and draw it at length; then take the Diſtance run 108 miles, and fix one foot of your Compaſſes in B, with the other cut the Meridian line D A, which it doth in A. Draw the ſide A B: then is B the place your Ship is at after her Sailing, A is the place of her ſetting out, A D is the Difference of Latitude and N O ſ is an Arch of 60 *deg.* from the Angle D A B (as a Center) the meaſure of N O is the Courſe, and is performed as before in the laſt Example; and alſo of the Difference of Latitude as in other Examples.

The Difference of Latitude is D B 90 miles.

The Courſe is North 33 *deg.* 45 *min.* Eaſterly, D A B or N O.

The Plain Scale of equal parts will not reſolve to the leaſt Fraction as the Tables will now to a tenth part of a mile, I confeſs a good Diagonal Scale will produce things to a ſmall Fraction.

If you would know what Latitude you are in, divide 90 by 60, and the Quotient will be degrees, namely, 1 *deg.* the Remainder minutes, namely 30 *min.* Now becauſe your Latitude was Northerly, and you have gone to the Northwards, you have increaſed it 1 *deg.* 30 *min.* ſo that you muſt add the Difference of Latitude to 50 *deg.* and it makes 51 *deg.* 30 *min.* if you have gone to the Southwards, you muſt have ſubtracted.



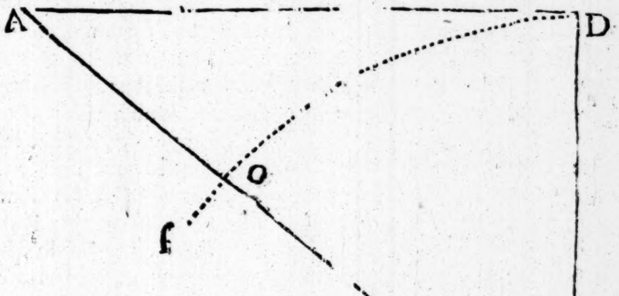
Difference

Difference of Latitude and Departure from the Meridian given, to find the Courſe and Diſtance run

QUESTION VI.

Admit the Departure from the Meridian of the Lizard *that I make be* 89 *miles* 8 *tenths of a mile, and I am in the Latitude of* 51 deg. 0 min. *I demand how the* Lizard *bears off me, and what diſtance I am from it, provided that I ſail between the North and the Weſt.*

FIrſt, draw a North and South line, and upon it ſet off the Difference of Latitude, which is D B 60 miles; then from the Northermoſt part of your Difference of Latitude, which is D, raiſe a Perpendicular, Eaſt and Weſt line, and ſet off your Departure from the Meridian upon it, from D, which falls at A: Then from A draw A B, for the Diſtance run; and becauſe B is the place you ſet from, let it be the Cen-



ter of the Arch of 60 *deg.* ſ O D, on which the meaſure of the Courſe is O D, which muſt be meaſured, as you have been ſhewed, and alſo the Diſtance run A B.

The Courſe I find to be N W b W.

The Diſtance run 108 miles.

By Propoſition.

The Rule that we have uſed for reſolving all the Queſtions hitherto laid down was this.

That the Sine of every Angle is proportional to its oppoſite Side, or every Side is proportional to the Sine of its oppoſite Angle: and this ſerved where you had oppoſite things given, but here you have two ſides, and an Angle between them given, ſo that you have nothing oppoſite to any of them, therefore that general Rule is of no value here in this caſe; this is a general Rule for this caſe, That, As the Sum of the two given Sides is to their Difference; So is the Tangent of the half Sum oppoſite Angles, To the Tangent of the Difference of either of them: That is, as the Sum of D B and D A together, is to their Difference, So is the Tangent of the half of A and B, to the Tangent of their Difference. Which Angle added to the half Sum makes the greateſt, or ſubtracted from the half Sum it makes the leaſt Angle. But this Rule though it be rare and true, yet in right angled Triangles we have a briefer way, which we will uſe, and leave this till we come to Oblique Triangles, as a place fitter for it: I only named it here, becauſe I would give notice that my Father in ſaying all, he means [illegible], for he ſaith (Axiom 3. Book 1.) *All plain Triangles,* &c. The reaſon why this Rule is not ſo good here, is this, if you ſubtract the Right Angle which is here always known from 180 *deg.* the Remainder is 90 *deg.* the Sum of the unknown Angles together, the half of which is 45 *deg.* now 45 *deg.* is the Radius of a Tangent, which is indifferent whether you take it or no, for it muſt be caſt away in your work: and therefore if you only take the Logarithm anſwering to the Sum of the two Sides comp. arith. and the Logarithm of the Difference of them and add them together, they will produce this Angle of the Difference, which added to 45 *deg.*

is the greater or ſubtracted is the leſſer; but which is better, you may do it with leſs trouble this way. Say for the Courſe,

As the Difference of Latitude 60 *miles comp. arith.*
Is to Radius
So is the Departure from the Meridian A D 89 8 *tenths*
To the Tangent of the Courſe A B.

Or, As the Departure is to Radius; So is the Difference of Latitude to Tangent Complement of the Courſe, Tangent A.

We will work it in tenths.

As Diff. of Latitude 600 *tenths* B D *comp. arith.* 7,2218487
Is to Radius
So is the Departure 898 *tenths* A D 2,9532763
To the Tang. of the Courſe, Tan. B 56 d. 15 m. 10,1751250

Now the Angle comes out to a minute of a degree. And thus you have your deſire at once; but this will be thus in none but right angled Triangles (whereas I ſaid before the Radius of a Tangent 45 *deg.*) is always half the Sum of the required Angles.

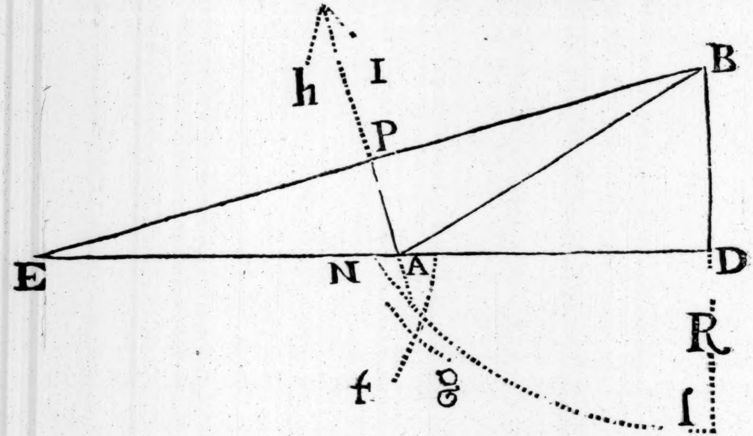
Note, that you always begin with the Side that is not oppoſite to the Angle you would have, and then you will put the Side that is oppoſite to the Angle in Proportion, with the Tangent of it; and thus for any other right angled Triangle of this nature:

Difference of Latitude given alone, Difference of Longitude and Diſtance run in one intire Sum, I demand the Courſe and Sides ſeveral.

QUESTION VII.

Admit I ſet from the Latitude of 50 deg. *and ſail upon ſome Point between the South and the Weſt, till I come into the Latitude of* 49 deg. 0 *min. (by Obſervation.) Now thoſe that keep account of things, tell me, that the Diſtance that the Ship hath run, and the Departure from the Meridian, is together* $197\frac{8}{10}$ *miles: I demand them ſeveral and the Courſe.*

IN this caſe (becauſe it would take up more room than my Book would hold) I'll make every 10 upon my Scale of equal parts 20, then every one of the ſmall diviſions will be 2. For the protracting of it Geometrically, firſt draw the North and South line B R at length, and upon it ſet off your Difference of Latitude, which is D B, make B the place of your Ships ſetting out, becauſe it is the Northermoſt Latitude, and your Difference of Latitude is Southerly, raiſe a Perpendicular (or



Eaſt and Weſt line) from D, and it muſt cut through the place where the Ship is; becauſe ſhe is in that Parallel or Latitude: upon this Eaſt and Weſt line, from D ſet the Diſtance run, and Departure together, which is 197 miles $\frac{8}{10}$, and it reacheth to E: by E and B draw the line E B, and divide it into two equal parts by a Perpendicular (you ſee it is a Perpendicular by the Arches h I and f g) draw it from P, till it cuts the Parallel E D, which it doth in A; from A then draw a line to the place you propoſed to your ſelf the Ship ſet from, which is B; now the length of that line, namely, A B, ſhall be the Diſtance run, and A D the Departure from the Meridian.

Demonſtration.

BE is divided into two equal parts in P, then E P and P B muſt be equal, P A is a Perpendicular to E P and B P, then muſt **AB** and **AE** be equal, becauſe the Perpendicular P A ſerves for them both, and their Baſes, or the ſides E P and P B are equal, as was ſaid before.

It is evident then, that B A and A D are equal to E D, for if E A added to A D makes E D, A B which is equal to AE, added to A D muſt be the ſame: and thus A B is the Diſtance run, and A D the Difference of Longitude or Departure from the Meridian, meaſure them as before; alſo from B as a Center, deſcribe the Arch of 60 *deg.* SN, and extend the Sides A B and B R to it, and meaſure the Angle of the Courſe A B D (as before) whoſe meaſure is N ſ, And thus much for the Geometrical way of working and demonſtrating.

The Diſtance run A B is 108 miles: The Departure from the Meridian AD is 90 miles: The Courſe is S W b W.

By the Tables.

I conſider that the ſide D B (the Difference of Latitude) and D E the Diſtance run and Difference of Longitude together are given in the Queſtion at firſt; whereby we may by the laſt Example, find the Angle at E, in the right angled Triangle B D E: Thus

For the Angle at E *and ſo for the Courſe.*

As DE *Diſt. run, and Depar.* 197 $\frac{8}{10}$ *which is* 1978 *tenths*	*comp. arith.*	6,7037736
Is to Radius		
So is the Difference of Latitude D B 600 *tenths*		2,7781512
To Tangent E 16 deg. 53 min.		9,4819248

The Complement of which to 90 *deg.* is E B D 73 *deg.* 7 *min.*

Now becauſe the Angle P E A and P B A is equal, ſubtract the Angle E B A from E B D, and the Remainder is A B D the Courſe

Example.

E B A 16 *deg.* 53 *min.* equal to A E P, ſubtracted from E B D 73 *deg.* 7 *min.* the Remainder is ABD 56 *d.* 15 *m.* the Courſe.

The reaſon that I take 3 from 7, and ſet down 5 is, becauſe if you look to the abſolute minute, and part of a minute of the

Arch that anſwers to this artificial Tangent 9,4819248, it will fall to ſuch a Fraction, or to be the 15 part of a minute leſs than 3, as will bring it out; but it is needleſs to be ſo exact in caſes or Queſtions of this nature.

I will not ſhew how to work that, till I come to a work that requires ſuch exactneſs; here you ſee if you take it without allowing for the Fraction, it is but 1 *min.* leſs or more, which is but the 675th. part of a point of the Compaſs, but to go to the exactneſs of it, it is the ſame.

For the Departure from the Meridian A D.

As Sine comp. the Courſe A B D 56 d. 15 m. *co. ar.*	0,2552609
To the Difference of Latitude 600 *tenths* B D	2,7781512
So is the Sine of the Courſe 56 deg 15 min. A B D	2,9198464
To the Departure from the Meridian A D 898 *tenths*	9,9532585

Which divided by 10, brings out 89 miles 8 tenths 89 (8(89
of a mile, as it was in the former Examples. xx2

To find the Diſtance run A B.

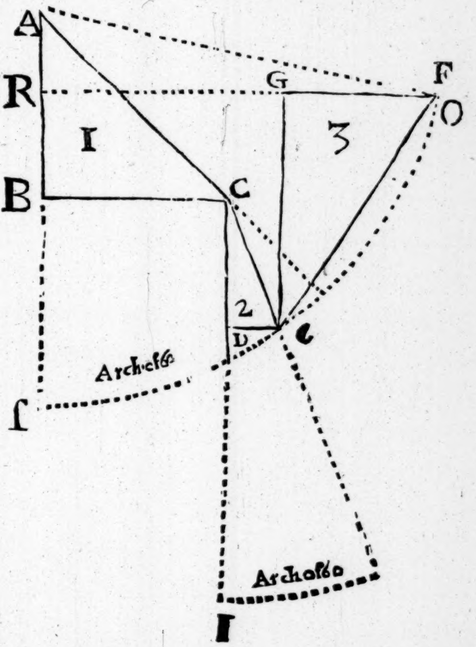
As Sine com. A B D *the Courſe* 56 d. 15 m. *co. ar.*	0,2552609
To the Difference of Latitude 600 *tenths* B D	2,7781512
So is Radius to the Diſtance A B 108 *miles*	3,0334121

A TRAVIS.

Admit I ſet from Sommars *Iſlands lying in the Latitude of* 32 deg. 20 m. *North Lat. and ſail S E* 40 *leagues; from thence S S E, till I alter my Latitude* 1 d. 0 m. *from thence upon ſome point between the North and the Eaſt* 40 *leagues, till I alter my Lat* 1 d. 45 m. ***I demand what Lat. I am in, my Diſtance run upon a ſtreight line, my Departure from my firſt Meridian, and my Courſe made good.***

FOr the doing this Geometrically, I have the Diſtance run, and the Courſe given; to lay down the Triangle A C B, make A the place you ſet from, and lay it down as was ſhewed in an Example of that nature before, *Queſt.* 3.

Then it is ſaid, from thence I ſailed S S E, till I altered my Latitude 1 *deg*. or 20 leagues; which ſignifies that from C is the place I altered my Courſe; therefore from C draw a South line, which muſt be parallel to A B ſ; Conſider what you have given, and work as hath been ſhewed in an Example of that nature, *Queſt*. 1. be ſure to ſet your Angles the right way: After that Angle is worked, I find my Ship is at e, then from e, draw the North line e G parallel to the firſt North and South line (for the Courſe is Northerly) and work your Triangle as hath bin ſhewed in an Example of that kind *Queſt*. 4. where the Difference of Latitude and Diſtance run is given, and you will find your Ship at F; let fall a Perpendicular from F upon the firſt Merid. line (which falls at R) and the length of it is the Departure from your firſt Meridian that you have made; likewiſe it cuts that Meridian, ſo that it leaves the Difference of Latitude R A, that you have made ſince you ſet out; then if you draw the line A F, it is the Diſtance that your Ship is now from the place ſhe ſet from; and if you deſcribe your firſt Arch of 60 *deg*. from ſ to O, and extend your ſide A F to it, it gives the meaſure of the Courſe ſ e O: Note that your Difference of Lati-



Latitude is Southerly, and therefore you muſt caſt it into degrees and minutes, and ſubtract it from 32 *deg.* 20 *min.* (your firſt Latitude) and the Remainder is the Latitude you are in; whereas if you had been in a Southern Latitude, and had differed your Latitude farther Southerly, you muſt have made your Latitude ſo much more, by adding your Difference of Latitude, as here, if you had gone to the Northwards, you muſt have done ſo, to have known your increaſe of Latitude Northerly: The like is to be underſtood in any caſe elſe of this nature. Here following I have anſwered the demands.

The departure from the firſt Meridian is F R 56 leagues.

The Courſe is the meaſure of the Arch ſ e O, which is E S E 9 *deg.* 8 *min.* Eaſterly.

The Diſtance that I am from the Port I ſet is A F 57 leagues.
Diff. of Lat. made ſince I ſet out is R A 13 leagues or 00 *d.* 39 *m.*
Which ſubtracted from the Latitude I ſet from 32 20
The Remainder is the Latitude you are now in 31 41

And thus you ſee you ſailed from A to C, and then altered your Courſe, and ſailed from C to e, and then from E to F; the like is to be underſtood of any Travis elſe. And thus if you had a Travis of 24 hours, you might find what Diſtance your Ship is from the place ſhe was the day before, and the other things, as Difference of Latitude, the Latitude you are in, the Departure, the Courſe made good upon a ſtreight diſtance; ſo that you need not ſet down every thing to every alteration in your Reckoning which is endleſs and fruitleſs.

By the Tables.

To give an anſwer to the demands in the Travis, you need find nothing but the Difference of Latitude, and Departure that is made in every Angle and note which way it is, either North or South for Latitude; Eaſt or Weſt for Longitude, and taking this notice after you have done, ſee which is greateſt, (in the Difference of Latitude) either the Northing or Southing, or for Longitude the Eaſting or Weſting, and that which is greateſt, that way it is, and ſo much as it is above the other: We will ſhew an Example of this, when we have wrought the Travis.

I mind the Travis, and I find I have the Courſe and Diſtance run in the firſt Triangle, to find the Difference of Latitude and Departure.

For the Departure.

As Radius	
To the Diſtance run A C 40 *leagues* 400 *tenths*	2,6020600
So is the Course B A C 45 deg.	9,8494800
To the Depar. BC 283 *tenths or* 28 *leag.* 3 *tenths*	2,4515450

28 leagues 3 tenths Eaſt Departure.

For the Difference of Latitude.

Foraſmuch as the Angle oppoſite to the Difference of Latitude, is equal to the Angle oppoſite to the Departure, namely, both 45 *deg.* the Sides will be alſo equal, therefore is A B the Difference of Latitude South 28 leagues 3 tenths.

For the Second Triangle.

Here I have given the Difference of Latitude and Courſe to find the Departure from the Meridian, which is all I need.

As Sine com. the Courſe D C E 22 d. 30 m. *co. ar.*	0,0343846
Is to the Diff. of Latitude 20 *leagues or* 291 *tenths*	2,3010300
So is the Sine of the Courſe D C E 22 deg. 0 min.	9,5828307
To the Departure D F 8 $\frac{8}{10}$ *leagues or* 88 *tenths*	1,9182543

The Departure is 8 leagues 8 tenths Eaſt, becauſe the Courſe is Eaſterly.

For the third Triangle.

In the third Triangle I have given the Difference of Latitude, and Diſtance run, to find the Departure.

For the Courſe.

As the Diſtance run G F 40 *leagues comp arith.*	7,3979399
Is to Radius	
So is the Difference of Latitude G e 35 *leagues*	3,5440680
To the Sine comp. of the Courſe f G F e, *the comp. of which is the Courſe* G e F 28 deg. 58 min.	9,9420079

For the Departure

As Radius	
To the Diſtance 40 *leagues*	2,6020600
So is the Courſe 28 deg. 58 min.	9,6851151
To the Departure 19 $\frac{4}{10}$ *leagues*	2,2871751

The Departure is Eaſt, becauſe the Courſe is Eaſterly.

Thus now in every Angle you know the Difference of Longitude and Difference of Latitude in leagues, and alſo which way either North or South, Eaſt or Weſt, ſet them down apart thus:

Lon. Eaſt.	*Lon. Weſt.*	*Northing.*	*Southing.*
28 $\frac{3}{10}$	00	00	28 $\frac{3}{10}$
8 $\frac{3}{10}$	00	00	20
19 $\frac{4}{10}$	00	35	00
56 $\frac{1}{10}$	00	35	48 $\frac{3}{10}$

Here I have added them up, and I find no Weſt Longitude, ſo that the Departure from the Meridian is Eaſt 56 leagnes $\frac{1}{10}$, the Difference of Latitude North I find to be 35 leagues, the Difference of Latitude Southerly is 48 $\frac{3}{10}$, ſubtract the Northing which is leaſt from the Southing, and the remainder is the Difference of Latitude in the whole run 13 leagues $\frac{3}{10}$; if you had Weſt Longitude, you muſt have ſubtracted thus likewiſe, and that which was greateſt the remainder belongs to.

OF A

RECKONING.

FRom what hath been already ſhewed, you underſtand, that if the Latitude of two places be known, and the Difference of Longitude between them, you may find the bearing of them one from the other, their diſtance aſunder, or any thing you deſire; and this is all ſo plain, that if I ſet from a place, and am bound to a place, whoſe Latitude is known, and the difference of Longitude alſo known between them, and keep a reckoning of the departure both Eaſt and Weſt that I make, ſetting them down in two diſtinct Columns; it is but ſubtracting one from the other, and the remainder will be the Eaſt or Weſt Longitude that I have made, (that of the two which was moſt,) alſo, if I know what Latitude I am in, and what Latitude the place lies in, it is but ſubtracting the leſſer from the greater, and the remainder will be the difference of Latitude between your ſhip and that place (provided the Latitudes be both one way.) Alſo, ſubtract the Difference of Longitude that you have made, (provided that it be that way which ſhortens your Longitude between the place you ſet from, and are bound to,) from the whole difference of Longitude between the two places, and the remainder will be what is ſtill between you and the place you are bound to: but if your departure which you have made, hath increaſed the difference of Longitude between the place you ſet from, and are bound to, add the remainder (after your ſubtracting the Columns one from the other) to the whole difference of Longitude between the places; the like for Latitude.

Example in the Reckoning *following.*

Suppoſe the Iſland of *Ditiatha* lies ſo, that it hath been found to have 950 Leagues departure Weſt, from the Meridian of the *Lizard* (according to the Courſes that be ordinarily ſailed by *Plano*) the Latitude of it is 16 *deg.* 16 *min.* North Latitude, the *Lizard* lies in the Latitude of 50 *deg.* 00 *min.* Now upon ſome Occaſion that fell in the term of our Voyage, namely, the 29th. of *January* on *Tueſday*, the Captain demands of me, what Diſtance *Ditiatha* was from me by *Plano*, how it bears, what Leagues of Departure I have to it, and the like: I look in my Reckoning, and I find in the Weſt Column 434 Leagues, I look in the Eaſt Column and ſee 60 Leagues; I ſubtract 60 (my whole Eaſt Column) from 434 (the whole Weſt Column) and the Remainder is 374 Leagues; which ſignifieth the Ship hath departed from the Meridian of the *Lizard* 374 Leagues Weſt; for the Weſt Column was greateſt.

Subtract this Weſt departure 374 Leagues, from 950 the whole Departure, and I find there is ſtill wanting 576 Leagues; This 576 Leagues is the Departure that is from the Meridian that my Ship is in, and *Ditiatha*.

Subtract alſo the Latitudes one from the other, (namely, the Latitude your Ship is in, and the Latitude of *Ditiatha*) and the Remainder is the Difference of Latitude in degrees and minutes between the Ship and the Place you are bound to, which in this Example I find to be 6 degrees 24 minutes. Take the Latitude out of the Column of Latitude for that day in the Reckoning, and you will find it ſo, if you ſubtract 16 *deg* 16 *min.* from it.

Thus you have the Difference of Latitude between you, that day, and your Port, and the Departure that the Port hath from the Meridian that you are in that day, given you to find the things demanded; I will not work it, for it hath beeen ſhewed ſufficiently already.

I have here following ſet down a Reckoning, and afterwards how I work it, and laſtly the reaſon that makes me uſe this way of keeping my whole Reckoning in the laſt line, ſo that I am not troubled to add it up, when I give account of it.

January *the* 3^d Anno Dom. 1655, *we departed from the* Lizard, *lying in the Latitude of* 50 d. 00 m. *being bound for* Ditiatha, *which lies in the Latitude of* 16 d. 16 m. *it having Weſt Departure from the Meridian of the* Lizard 950 *Leagues (according to the courſes which we then ſteered) at* 4 *of the clock, the* Lizard *bore from us* N N E, *about* 6 *leagues diſtance by eſtimation.*

D. M.	*Week days.*	*Latitude*		*Dep. E. in leag.*	*Dep. W. in leag.*
		deg.	*min.*		
4	Friday	49	00	000	021
5	Saturday	47	55	000	059
6	Sunday	46	20	000	085
7	Munday	45	00	000	088
8	Tueſday	43	E 54	000	108
9	Wedneſday	42	4	000	147
10	Thurſday	41	E 19	000	262
11	Friday	41	10	000	264
12	Saturday	40	46	000	274
13	Sunday	40	45	000	178
14	Munday	39	E 49	000	179
15	Tueſday	37	E 24	000	200
16	Wedneſday	35	59	000	229
17	Thurſday	34	42	000	249
18	Friday	33	15	000	278
19	Saturday	31	15	000	322
20	Sunday	29	5	000	364
21	Munday	28	E 20	000	400
22	Tueſday	27	5	012	400
23	Wedneſday	27	30	022	400
24	Thurſday	27	22	031	400
25	Friday	26	E 49	049	400
26	Saturday	25	36	060	400
27	Sunday	24	31	060	406
28	Munday	23	28	060	406
29	Tueſday	22	E 40	060	434
30	Wedneſday	22	08	060	434
31	Thurſday	21	53	060	444
		February.			
1	Friday	21	40	060	450
2	Saturday	20	47	060	456
3	Sunday	19	22	060	460
4	Munday	19	53	060	472
5	Tueſday	18	23	060	485

Every day at Sea you ſet down at noon that 24 hours work: Now I adviſe you to ſet it down as it is here: In the firſt Column on the left hand, I ſet the day of the Month, in the next the day of the Week, in the third the Latitude I am in by dead Reckoning or by Obſervation, only I make a diſtinction between them by the letter E, which ſtands for Eſtimation, and is ſet down only when I do not obſerve: that ſo you may know where to begin to correct. In the 4th. Column I ſet down the Eaſting, in the fifth column the Weſting.

The manner that I ſet my Eaſting and Weſting down is thus. Every day there is the Ships courſe minded, and an obſervation, whereby you have the difference of Latitude, and courſe to find the departure; or elſe if you cannot obſerve, you have the diſtance run, gueſſed at, and the courſe; to help your

D. M.	*Week dayes*	*Latitude* *deg.*	*min.*	*Dep. E. in leag.*	*Dep. W. in leag.*
6	Wedneſday	17	19	060	518
7	Thurſday	16	47	060	556
8	Friday	16	54	060	606
9	Saturday	16	29	060	643
10	Sunday	16	19	060	678
11	Munday	16	21	060	726
12	Tueſday	16	28	060	784
13	Wedneſday	16	35	060	840
14	Thurſday	16	27	060	889
15	Friday	16	24	060	929
16	Saturday	16	2	060	973
17	Sunday	16	44	060	1003

gueſs is the Log-line every 2 hours; your courſe and diſtance is ſet down upon the Log-board every 2 hours, whereby you may ſee it, and work it every 24 hours, to find the departure and difference of Latitude: Now whatſoever I find the departure to be, I add it from the firſt day all along thus: the departure when I ſet the Lizard (which was N N E 6 Leagues off) is 2 Leagues Weſt; I keep mind of that till the next day at noon, and I find what departure I have made from the Meridian that I was in the day before at noon (by the things I have given me) and here I found it was 19 Leagues, I add it to my departure from the Meridian Weſt yeſterday 2 Leagues, and it makes my whole departure Weſt 21 Leagues.

Again, the next day at noon, I work my Ships Travis, as hath been ſhewed, and I find that ſhe hath departed from the Meridian ſhe was in yeſterday 38 Leagues Weſt, which I add to what I had before, which was 21, and it makes 59 Leagues; and thus I go forwards, adding my laſt days departure in its true Column to all the reſt, (which is in one ſum) and by this means the laſt line is the whole Reckoning.

21
38
—
59

In the Eaſt Column I ſet Ciphers to fill it up, till I have ſome Eaſt departure to put in it, and as that increaſeth, ſo I add it (as the other) every day.

Alſo, I carry the Weſt departure along in its full number of Leagues in the ſame line, without increaſe or decreaſe, till ſuch time as I have more to increaſe it, and then I increaſe that, and carry the whole Eaſting with it in the ſame line: and thus you have need to look upon nothing, but the laſt line, to reſolve you any thing that you deſire, either of your courſe made good ſince you ſet out, your diſtance upon a ſtraight line that you have ſailed, your Ports bearing from you, what departure is yet between you and your Port, your diſtance to it upon a ſtraight line; for there you have your whole Weſting, and your whole Eaſting, and the Latitude you are in, as alſo the Latitude of the place you are bound to; whereby (as I have formerly ſhewed) you may find them.

If there be Longitude but one way, you will ſee nothing but Ciphers in the other Column: this way you ſee is done without a Plat. I hold a Plat to be neceſſary only to ſhew what dangers lie in your way, that ſo you may ſhape a courſe clear by it, and I ſhould uſe a Plat for nothing elſe, except it be for Coaſting, where it is really uſeful.

I commonly ſet down the Eaſting or Weſting between the place I ſet and the place I am bound to at the beginning of my reckoning, as alſo the Latitude of each place, as I have done here. You may ask why I do not ſet down the courſe that I made good every day: indeed that is not unneceſſary, but the reaſon why I omit it is, Firſt, becauſe I find it of little uſe in my Reckoning; and ſecondly, I find it can be better expreſſed in a Journal which is kept with my Reckoning; and indeed there I ſet it with the Winds, and the reaſons for ſteering upon ſuch Courſes: but I leave every one to their own Judgment for that, as alſo for Diſtances and Winds, for Difference and Variation.

It would have been neceſſary here to have ſet down ſome Tables to have worked Triangles by, for (as I have ſaid) ſometimes in 24 hours you have a Travis of 4 or 5 ſeveral courſes, and to work them this way may ſeem tedious. I commend you to my Fathers Practice, where there is as good Tables as can be, to every degree of the Compaſs; its uſe is eaſie, and works to the tenth part of a Mile or League.

CONCERNING the *VARIATION* OF THE COMPASS.

THere is always two things given to find the Variation of the Compaſs; that is, the true Amplitude of the Suns riſing, and the Magnetical Amplitude of the Suns riſing or ſetting: the true Amplitude of the Suns riſing, is, (as I have ſaid before in another place) the true and abſolute quantity of degrees, that the Sun riſeth from the Eaſt, (either Northwards or Southwards) or ſets from the Weſt, and is found (as I have before ſhewed) in the uſe of the Sphere.

The Magnetical Amplitude of the Sun, is what the Sun riſeth from the Eaſt, or ſets from the Weſt by the Compaſs: Now becauſe the firſt gives the Truth how far the Sun riſeth from the Eaſt, or ſets from the Weſt; therefore whatſoever difference there is between them, ſo much is the variation.

As now, Suppoſe I find in a certain Latitude ſuch a day of the Month (by the Sphere) that the Sun riſeth to the Northwards of the Eaſt 17 degrees; that is, the true Amplitude: but I obſerve the Sun at her Riſing, with an Azimuth Compaſs (which is made for that purpoſe) and find that ſhe riſeth but Eaſt 10 degrees Northerly; then I conclude the Variation is 7 *deg.* 0 *min.* or the Compaſs is falſe ſo much; ſo that whereas if I direct my Courſe Eaſt 10 degrees Northerly by the Compaſs, I do not go on that Courſe, but I go Eaſt and by North 5 *deg.* 45 *min.* Northerly, which is juſt 7 *d.* from my expectation, or Eaſt 17 *deg.* Northerly, the true Amplitude. Now that is a groſs error, and in long runs may deceive a man much, and perhaps be a means to loſe a Ship, when one little thinks of it; and therefore it ought to be looked to.

An Azimuth Compaſs is no other in effect, but a Compaſs fitted for the exact taking of the Sun at her Riſing or Setting, or upon other certain times of the day, as you may have occaſion.

In like manner you may find the Variation of the Compaſs at other times, by taking the Suns Azimuth at any time of the day.

Example.

Suppoſe I were in the Latitude of 33 deg. 20 min. *Northerly, and upon the* 8th. *day of* November *the Suns Declination is Southerly* 19 deg. 20 min. *I demand the Suns Azimuth at* 8 *of the Clock.*

The Suns Azimuth at her Riſing (as I have ſhewed) is the Complement of the Suns Amplitude; but after the Sun is up, it may be alſo the Diſtance of the Sun from the Eaſt and Weſt Azimuth: Now in this Propoſition, you deſire to know how many Degrees the Sun is from the Eaſt and Weſt Azimuth, (which is that Part of the Heavens that is diſtant from the Sun) parallel to the Horizon over the Eaſt Point of it; or if it had been at 4 of the Clock in the Afternoon, it would have been required from the Weſt Point.

For the reſolving this Queſtion project a Sphere (as hath been taught) for the Latitude propoſed, with the Parallel of the Suns Declination drawn as it is given: Divide this Parallel of Declination into the hours of the day from 6 to 12, or which ſerves from 12 to 6 in the Afternoon; the way to divide it is thus; From 6 of the Clock ſet off 15 degrees by the third way of meaſuring, which will be 7, then (becauſe 30 degrees is two hours in time) next ſet off 30 degrees by the third way of Meaſuring from 6, and it makes 8 a Clock; then take

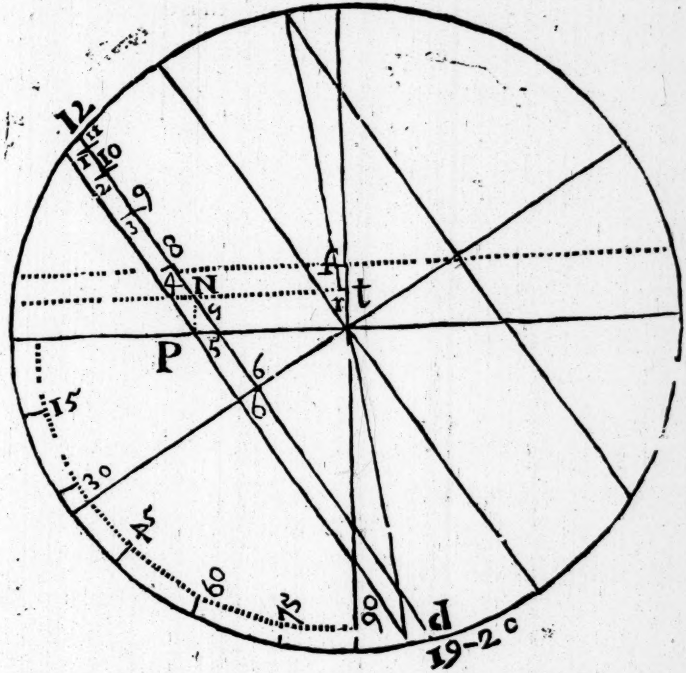
45 *deg.* which is three hours, and it makes 9 a Clock, then 60 *deg.* for 10 a Clock, then 75 *deg.* for 11 a Clock, and then 90 *deg.* which will juſt fall in the place where the Sun comes to the Meridian for 12 a Clock. Thus you divide the Parallel of the Suns Declination into hours, as you may ſee in the Sphere here following: it being thus divided, the Suns Azimuth at 8 of the Clock is 8 ſ, taken off by the third way of Meaſuring, I find it to be 33 *deg.* 0 *min.* (by the Scale) ſo it is certain that the Sun ſhould be juſt 33 *deg.* 0 *min.* to the Southwards of the Eaſt at 8 of the Clock, then I will ſee how high he ſhould be at that time, and I find him to be 13 *deg.* 50 *min.* equal to ſ ♈, take off ſ ♈ by the ſecond way of Meaſuring. I will obſerve the Sun till I find him at that height, and then I know it is 8 of the Clock; ſee by your Azimuth Compaſs whether he be 33 *deg.* 0 *min.* from the Eaſt or no, and if not, what it differs, ſo much is the Variation of the Compaſs.

I have wrought this Example no nearer than the plain Scale works it, which poſſibly may be 15 *min.* or half a degree of the Compaſs out of the way, but that is no conſiderable error in a Courſe, which is the thing we here uſe it for.

The ſame may be done at any time of the day, as Latitude 32 *deg.* 20 *min.* North, Declination 19 *deg.* 20 *min.* South.

Suppoſe it were cloudy, but at ſome time the Sun breaks out, ſo that I have an opportunity to take his height with my Quadrant, and alſo his magnetical Azimuth with my Azimuth Compaſs: Now I find his height to be r t, equal to N P, and the Azimuth at that time is N t, it being drawn parallel to the Horizon; this N t ſet off by the third way of Meaſuring, and ſo much as it comes to, ſo much is the true Azimuth of the Sun from the Eaſt towards the South: Take your magnetical Azimuth at the ſame time, and as much as they differ, ſo much is the Variation: And thus much for the Variation of the Compaſs.

I have known ſome able men that have miſſed *Barbadoes*, and I have obſerved that it hath been moſt commonly, when the Sun



Sun hath had North Declination, ſo far that he hath been to the Northwards of that Latitude. Now I ſuppoſe the reaſon of it may be this.

When a man obſerves the Sun with a Quadrant (which is our uſual Inſtrument) he takes the upper edge, which is to the Northwards in this Latitude. Suppoſe then I ſet from the *Lizard*, and am bound to *Barbadoes*, I make obſervations of the Sun as often as I can all the way, till I bring the Sun to the Zenith: after I paſs the Zenith, the edge of the Sun that was higheſt is loweſt: Now he that doth not conſider this, loſeth the bredth or Diameter of the Sun, ſo that your obſervations may differ from your expectation 30 miles, which is enough to miſs an Iſland; therefore I adviſe you always to allow the Suns Diameter (which ſome count 30 *min.*) to every obſervation you make in places where the Sun is to the Northwards of you; that is, make your Meridian Altitude 30 *min.* leſs than it is, which is the Altitude of the lower edge, which was your upper edge before you croſſed the Zenith, where the Sun was; or if you work your obſervations by the Complement of his height, make that 30 *min.* more.

I confeſs the beſt way would be at all times to ſubtract the Semidiameter of the Sun, which is 15 *min.* from your Meridian Altitude: But becauſe the Latitude of Places are not ſet down with this conſideration, it is more ſafe to do as before, unleſs you know otherwiſe by your own experience. This only by the by to give notice.

Example, for the laying open of this Error.

Suppoſe I obſerve the Sun at *Barbadoes* the 11th. day of *December*, and I find that the Meridian Altitude of the Suns upper edge is 53 *deg.* 18 *min.* to which I add the Suns Declination for that day, which is Southerly 23 *deg.* 30 *min.* and it gives the height of the Æquinoctial above the Horizon of the Complement of the Latitude to 90 degrees, which is 76 *deg.* 48 *min.* which ſubtracted from 90 degrees, leaves the Latitude or Æquinoctial's Diſtance from the Zenith, 13 *deg.* 12 *min.*

Upon the 11th. of *June*, I obſerve the Sun again in the ſame place, and I find the Meridian Altitude of the upper edge of the Sun is 80 *deg.* 12 *min.* (Note that this upper edge is oppoſite to the edge before, for the Suns Declination is 23 *deg.* 30 *min.* Northerly, which makes that the Sun gives a South Horizon) I add the Suns Declination to the Meridian Altitude, and it gives 103 *deg.* 42 *min.* the Diſtance between the Æquinoctial and the North Horizon, from which ſubtract 90 *deg.* and the remainder is the Æquinoctial's diſtance from the Zenith, or the Latitude which is 13 *deg.* 42 *min.* Now this Latitude ſhould agree with the other, for the place ſtands ſtill; but for want of this ſubtracting the Semidiameter of the Sun, it differs 30 *min.* and when men meet with things thus at Sea, for want of minding of this they run 30 *min.* more Southerly than they ſhould do, which I ſuppoſe may be the greateſt reaſon of their miſſing this Iſland, and others that lie near the Æquinoctial; but for thoſe places that lie far from the bounds of the Sun, it is not to be minded: Yet it were good (methinks) if all Places had been laid down with allowance for the Suns Semidiameter; but becauſe they are not, you ought to be careful, when at any time you croſs the Zenith of the Sun: I have not been my ſelf in a time of year to croſs the Suns Zenith, and therefore I only ſet this down by way of Caution to thoſe that may.

The USE *of a* PLAIN
SEA-CHART.

MOſt Plats have all the Points of the Compaſs drawn out from ſeveral Centers through the Plat, and becauſe they are common, and the way to work by them ſo ordinarily known, I have thought it neceſſary to draw the manner of a Plat, and to ſhew its uſe that hath only Meridians and Parallels drawn in it, which is the Plat following.

Suppoſe then that I have a Plat that hath the Meridians and Parallels drawn to every fourth degree, as this following is. You ſee this Plat is divided into equal Squares throughout, by the Meridians and Parallels ſo drawn, alſo one of theſe Squares is divided into eight Points of the Compaſs, which is the Square E C D O, (the manner of dividing it we will ſhew anon.) Now if A where the *Lizard*, and B were the Iſland *Madera*, I demand their diſtance aſunder. Let BA repreſent the edge of a Scale lying between them, take the Diſtance A B, and apply it to the Meridian, and ſee how many degrees it reacheth, and convert them into miles, and it anſwers your deſire. If you cannot take the diſtance at once, take it at twice, and add the ſeveral Sums together, and convert them into miles: Then

For their bearing one from the other.

Imagine (as I ſaid before) that A B were the edge of a Scale cutting upon the two places. Look for that Corner that is neareſt without the edge (which is S) fix one foot of your Compaſſes in S, and with the other ſweep the edge of your Scale, which will be S G, keep faſt your Scale, and from the Corner S run that foot of your Compaſſes (keeping it at the ſame Diſtance from the Scale by the other foot running by the edge of the Scale) till you come to the next ſide with it (which in this example fails at F) then take the Diſtance E L, and apply it to the graduated Square, either from D or E, and as many points as it is there, ſo many Points doth the *Lizard* bear to the Eaſtwards of the North, from the *Maderas*, which is here two points and almoſt a quarter. The ſame will be done from a Corner farther from the Scale, and this is evident; for by the Flower de luys you ſee that S L is a North line from S, and a line drawn from S to F is parallel to B A, or runs upon the ſame point to the Eaſtwards of the North from S. Therefore whatſoever line S F is, the ſame is B A, the like is to be underſtood of any other example, as, ſuppoſe we had not found the bearing of the *Lizard* from the *Maderas*, and would find the bearing of the *Maderas* from the *Lizard*. Becauſe my Scale runs no farther than B, I cannot uſe the Corner at S (which is neareſt) and the reſt are upon the graduated Meridian, therefore I will uſe the Corner at L, as I did the Corner at S; but becauſe it is the contrary thing, I'll run the contrary way, namely from L to H, then is L H and F S parallel, and becauſe S L is the Meridian to them both, therefore are H S and L F equal, ſo that if S H be applied to the graduated Square, it is as many points to the Weſtwards of the South, as L F is to the Eaſtwards of the North, therefore the *Maderas* bear from the *Lizard* South South-weſt almoſt a quarter of a point Weſterly: if it had been from any other Corner, it would have been the ſame, the like for any other.

For the Departure from the Meridian between two Places.

Suppoſe X *were one Place, and* (||) *the other, and I would know the Departure or Difference of Longitude between them.*

Fix one foot of your Compaſſes in (||), and extend the other to ſweep the Meridian neareſt ſhort of the other place, which is the Meridian V, that Diſtance apply to the graduated Meridian, and ſee how much it is, then take the Diſtance from the other place (which is X) to ſweep the neareſt part of the ſame Meridian, and apply that to the graduated Meridian, ſee how much it is, and add it to the former, and it makes the whole Departure between the two places, X and (||), convert it into miles or leagues, according as you deſire; in moſt Plats you have a Scale or Leagues, which is neceſſary for ſmall Diſtances.

For the Difference of Latitude between two Places.

The Difference of Latitude between two places is taken after the ſame manner from a Parallel, as the Departure is from a Meridian Line; as ſuppoſe I would take the Difference of Latitude between X and (||), firſt, take the neareſt Diſtance between X and the Parallel that T is in, and ſee how much it is. Then take the neareſt Diſtance between (||) and the ſame Parallel, and ſee how much it is, and add them together, and that convert into miles or leagues according as you deſire.

To find what Latitude any place lies in, take the neareſt Diſtance between that Place and the next Parallel with your Compaſſes, and look where that Parallel cuts the graduated Meridian, and carry your Compaſſes with that diſtance there (one foot) and obſerve to ſet the other that way as the place is, either to the Northwards or Southwards of that Meridian, and ſee upon what degree and minute of a degree it falls, and that is the Latitude of the place.

As, ſuppoſe I would know the Latitude of the North ſide of the *Maderas*, I will fix my Compaſſes, one foot in B, and extend the other to ſweep the Parallel that S is in, that Diſtance I will carry to the place were the Parallel cuts the graduated Meridian which is at 34, and fixing one foot there, I will ſee where the other falls to the Southwards towards L (becauſe it is the Southwards of that Parallel) and I find it falls in the Latitude of 32 *deg.* 30 *min.* from whence I conclude, that the Northermoſt part of the *Maderas* lies in the Latitude of 32 *deg.* 30 *min.*

The way that the Square E C D is divided into Points, is on this manner: Firſt, I draw the line O C, then the other lines for half-points, and quarter-points, then I deſcribe the Circles, making the outmoſt come to the innermoſt of the lines (but whether it be or no is no great matter) the Circles being divided into Points, half-points, and quarters, I lay my Scale by the Center of theſe Circles, which is O, and the diviſions on the Circles, & where my Scale cuts upon the outer line, from thence I draw my Points, half-points, and quarter-points, as you ſee here in the following Blank; and the Points upon the ſides of the Square thus ſet off are the Tangents of the Points upon the Arch: for when from the outermoſt edge of an Arch a Perpendicular is raiſed from a ſide that bounds that Arch (as the ſide N 4 is,) and the other ſide that bounds the ſame Arch be extended without the Arch to interſect it (as the line O C interſects N 4 at 4,) that Perpendicular is the meaſure of that Arch, either in degrees or points; as here N W is 45 degrees or 4 points, and ſo is N 4. And thus you may divide a Tangent line for degrees or points, from an Arch divided into degrees or points.

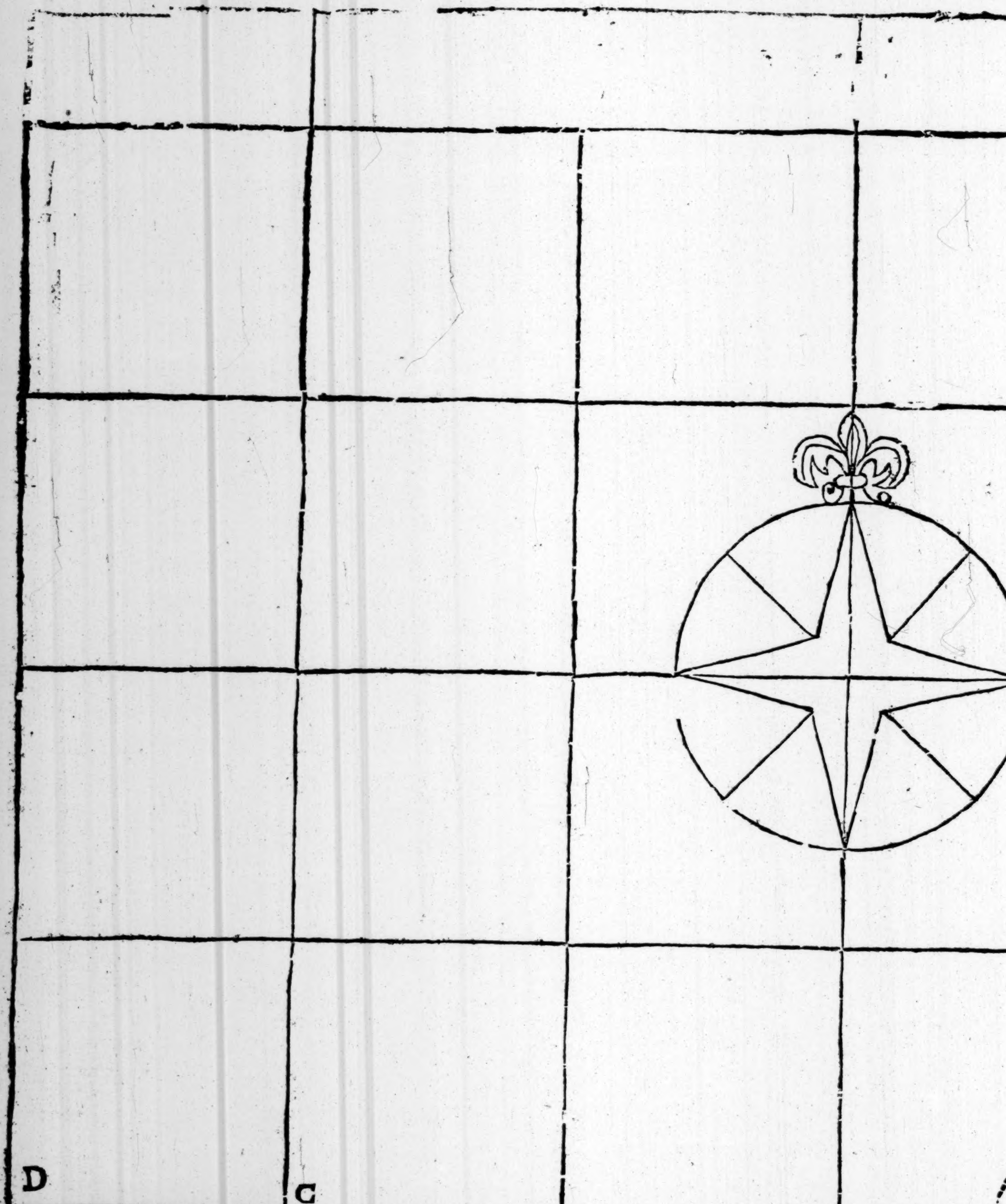
To ſet off any Courſe from a Place aſſigned upon a Blank.

Let the Place aſſigned be X, *from which I would draw a* N W b N *line.*

Take three points from the graduated Square (making D or E the place you take it from) and fix one foot of your Compaſs in the next convenient Corner to X (which is at M) and ſet off the three points which fall at K; then from the next Corner upon the ſame Meridian that M is, (and to the Southwards of it) which is at P, lay your Scale to K, then your Scale lieth N W b N from

P,

P, and a line Parallel to the Scale from X muſt be a NWbN line, the like for any Courſe elſe, obſerving the quarter of the Compaſs, it is to be ſet off in, as alſo whether it be nearer the Eaſt or Weſt than the North or South; for if it be nearer the Eaſt or Weſt than the North or South, you muſt do the ſame from a Parallel, as here you did from a Meridian; for the ſide of a Square is but the meaſure of four points, which is but half the points between a Meridian and a Parallel. This way of working may ſeem hard and tedious at firſt, but you will ſoon find that it is free from miſtakes, and both exact and eaſie, if you practiſe it.



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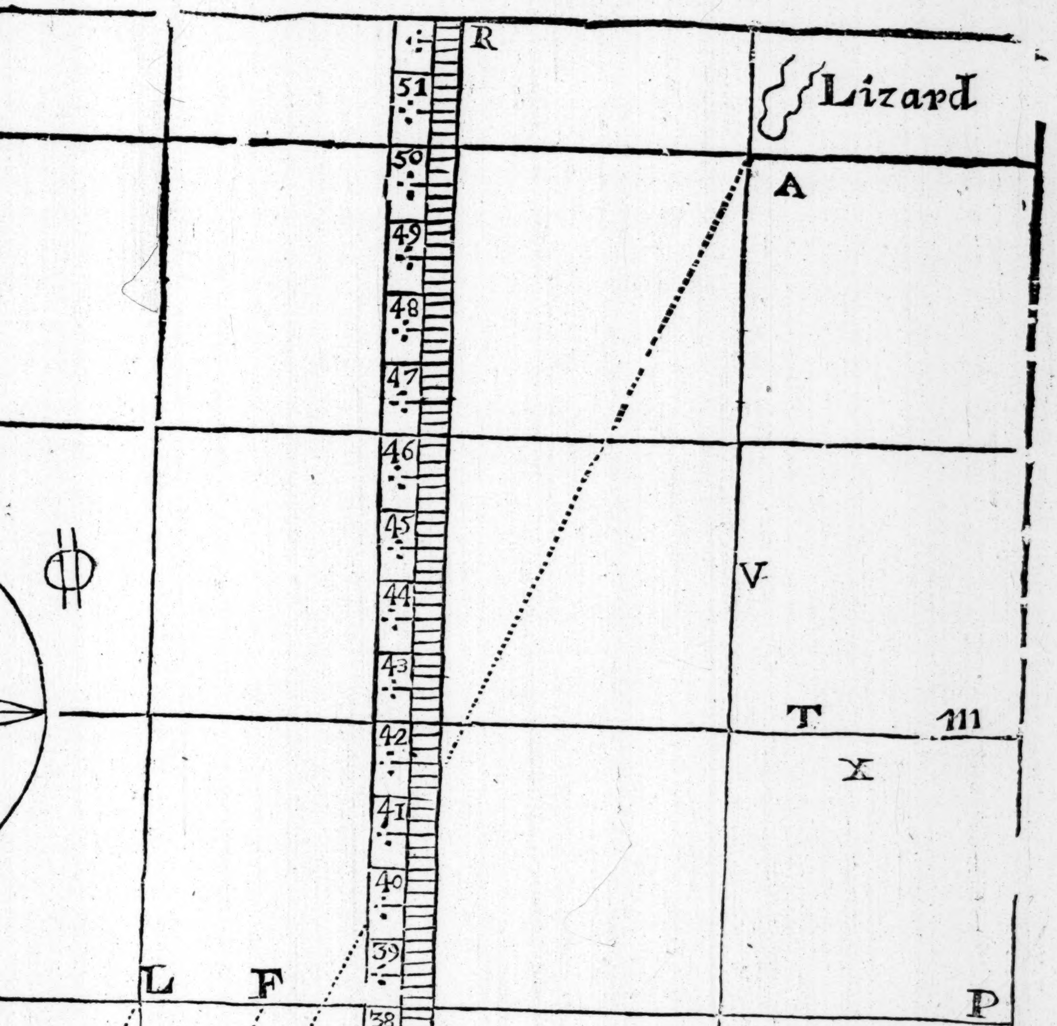


age 112 and 113.

Of Oblique
TRIANGLES.

Two Sides with an Angle oppoſite to one of them given, to find the other Angles and Side.

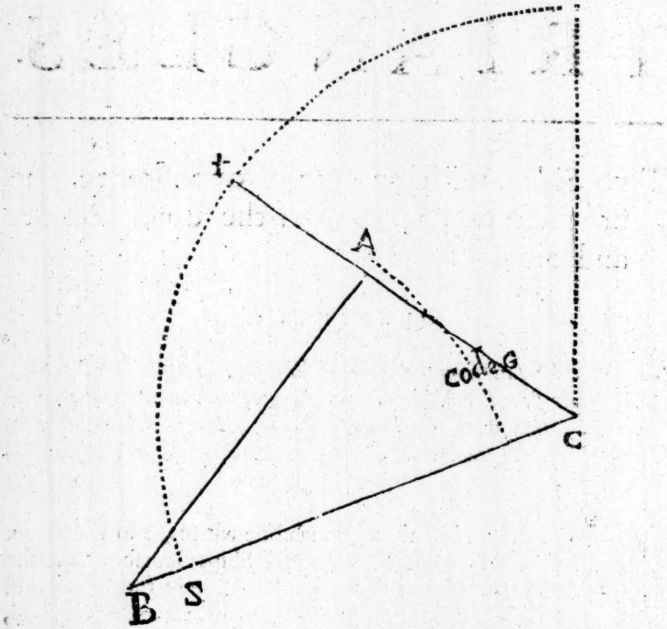
Question I.

Two Ships ſet ſail from the Rock of Liſbon, *one ſailed* W S W, *the other ſailed* N W b W 38 *leagues, and at the end of their ſailing, they were* 58 *leagues aſunder, I demand the Southermoſt Ships Diſtance run, and how the Ships bear one from the other?*

First draw a North and South line white, and then from that ſet off the Northermoſt Ships Courſe, make the Rock or Place ſetting out the Place in the North and South line that you draw that Courſe from, which is C, upon this Courſe ſet off 38 leagues (becauſe the Queſtion ſaith you ſailed 38 leagues upon it) and extend the ſide C A to the Arch of 60 *deg.* at t, and ſet off five points from t to S, and draw S C a white line, which is W S W Courſe: (for it is five points between the W S W and the N W b W) this done, take 58 leagues from the Scale of equal parts, and fix one foot of your Compaſſes in A, and where the other interſects the Courſe B C (which it doth in B) there is the other Ship, then to meaſure the Angle of the Ships bearing one from the

other

other it is B, and B C is an E N E line; extend B A to the Arch of 60 *deg.* whoſe Center is at B, and ſee how many degrees or points it is more Northerly than an E N E line, and ſo the other Ship (namely, the Ship at A) bears from the Ship at B;



then take the length of B C, and apply it to your Scale, and ſee how many leagues or miles it is. I have wrought this in leagues, but I will work the reſt in miles, becauſe it is more exact. I find that the Ship at A bears from B, N E b N 45 *min.* Eaſterly, the Diſtance run of the Southermoſt Ship is 70 leagues.

By

By the Tables.

The proportion of this and all others of this kind, is the ſame that holds in right angled Triangles; namely, that the Sine of every Angle is proportional to its oppoſite ſide, or every ſide is proportional to the Sine of its oppoſite Angle.

Here we have given the ſide C A 38 Leagues, the ſide A B 58 Leagues, and the Angle at C which is 5 points or 56 *deg.* 15 *min.*

Say then for the Angle at B.

As A B 58 *leagues*, 580 *tem.*	*comp. arith*	7,2365719
Is to A C B 56 *deg.* 15 *min. Sine*		9,9198464
So is A C 38 *leagues* , 380 *tem.*		2,5797836
To A B C *Sine* 33 *deg.* 0 *min.*		9,7362019

Which ſubtract from 6 points or 67 *d.* 30 *m.*
33 00

Remainder is the Courſe from North 34 *d.* 30 *m.*

Which the Ship A bears from the Ship B, which is N E b N 45 *min.* Eaſterly.

For the Diſtance run of the Ship at B, *the Side* B C.

As Sine C 56 *deg.* 15 *min.*	*comp. arith*	0,080153
Is to A B 58 *leagues*		2,763428
So is Sine B A C 90 *deg.* 45 *min.* *Take the Sine of the acute Angle* B A t	} 89 *d.* 15 *m.*	9,999961
To B C 68 $\frac{8}{10}$		2,843542

The reaſon why you take the acute Angle is, becauſe the Tables go no further than 90 *deg.* neither indeed is any Sine beyond 90 *deg.* but (as my Father ſaith in his *Trigonometry*, p. 2[illegible]) the Sine of an Arch leſs than a Quadrant is alſo the right Sine of an Arch as much greater than a Quadrant: So then the right

Sine of the Arch 90 *deg.* 45 *min.* which is 45 *min.* greater than a Quadrant, muſt be the right Sine of the Arch 89 *deg.* 15 *min.* which is as much leſs (namely, 45 *min.*) the Geometrical Demonſtration of it is there laid down.

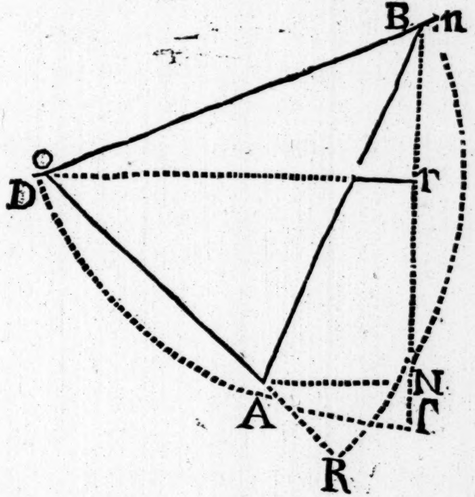
You may ask how I came to know the Angle B A C, which was thus: I found one of the other two Angles, namely B, and the other I had given me, I added them both together, and that Sum I ſubtracted from 180 *deg.* the Remainder muſt then be the Angle at A, becauſe 180 *deg.* is the Sum of the three Angles of any right lined Triangle: And if I ſubtract two of them from three of them, there will remain one of them, which was 90 *deg.* 45 *min.*

The three Angles of a Triangle given, with one of the Sides, to find the other two ſides.

QUESTION II.

Admit I ſet from a Head-land lying in the Latitude of 50 deg. 00 min. *North Latitude, and ſail* W S W 38 *Leagues, and then meet with a Ship that came from a Place which lies* S S W *from the Head-land. Now this Ship hath Sailed* N W. *I demand the Diſtance of that Place from the other, and alſo the Diſtance the Ship hath ſailed that came from the Southermoſt Place.*

FIrſt draw your North and South line B ſ. Let B be the Head-land. From B then draw a W S W line (by deſcribing the Arch of 60 *deg.* ſ D from the Center B, and ſetting it off as hath been ſhewed) upon this W S W line ſet off the Ships run 58 miles B O. From O as a Center deſcribe the Arch of 60 *deg.* R n, and extend the ſide O B to it: Now becauſe the Queſtion ſaith that B O is a W S W line from B, then O B muſt be an E N E line from O. Alſo becauſe the Queſtion ſaith, that the Ship that met her ſailed N W, the ſide A O is a N W line from A, which is a S E line from O to A. Now there are 6 points between an E N E and a S E Courſe: therefore from the line D B extended upon the Arch of 60 *deg.* from B, ſet off 6 points or 67 *deg.* 30 *min.* which is n R, and draw O R a white line: Then becauſe the Queſtion ſaith that the place the other Ship ſet from, bears from the Head-land B S S W. Draw a S S W line from B, which is B A, and where



it cuts the line O R, which is in A, there will be the place the other Ship ſet from, and A B will be the diſtance of the Head-land and that aſunder, A O will be the diſtance that the Ship hath failed that came from it, which I find as followeth.

The diſtance between the two places is A B	58 *miles.*
The diſtance that the Ship ſailed is A O	44 $\frac{4}{10}$ *miles.*

If you have occaſion to find the Latitude the place at A lies in, let fall the Perpendicular A N upon the South line that comes from B, and it cuts it in N, and leaves the Difference of Latitude B N, ſee how many miles it is, and ſubtract it from 50 *deg.* and you have your deſire, meaſure A N, and you have the Weſting that A lies from the Head-land B.

By the Tables.

Here the Angle at B is an Angle of 4 points or	45 *d.* 00 *m.*
The Angle at A is an Angle of 6 points or	67 *d.* 30 *m.*
The Angle at O is an Angle of 6 points or	67 *d.* 30 *m.*
The ſide B O is 58 miles.	

Firſt for the Side AB.

The general Rule ſaith, That the Sine of every Angle is proportional to its oppoſite ſide. Then from this I conclude, that B A ſhould be equal to B O, becauſe the Angles oppoſite to them are equal, and ſo you will find them

For as Sine A 67 *deg.* 30 *min.*	*comp. arith.*	0,034384
Is to O B 58 *miles*		1,763428
So is Sine O 67 *deg.* 30 *min.*		9,965615
To AB 58 *miles, the two places diſtance*		1,763428

You ſee it is ſo exactly, for theſe three numbers added together, and Radius caſt away, produceth the ſame Logarithm that 58 (taken out of the Book) did, and this Queſtion I do on purpoſe to ſhew the truth of the general Rule. The ſame way other Queſtions of this nature are wrought.

For the Diſtance that the Southermoſt Ship ſailed, A O.

As AOB *Sine* 67 *deg.* 30 *min.*	*comp. arith.*	0,034384
Is to AB 58 *miles*		2,763428
So is Sine ABO 45 *deg.* 00 *min.*		9,849485
To AO $44\frac{4}{10}$ *miles*		2,647297

If you deſire to find the Difference of Latitude between the two places B and A, you have the Diſtance A B, and the Courſe A B n given to find it or the Longitude.

If you deſire to find the Latitude the Ships are in when they meet, let fall a Perpendicular from O upon the South line (which is B N) and you have the diſtance O B given, 58 miles, and the Angle O B R 67 *deg.* 30 *min.* to find it, or the Departure between the Ships at their meeting, and the Head-land O r.

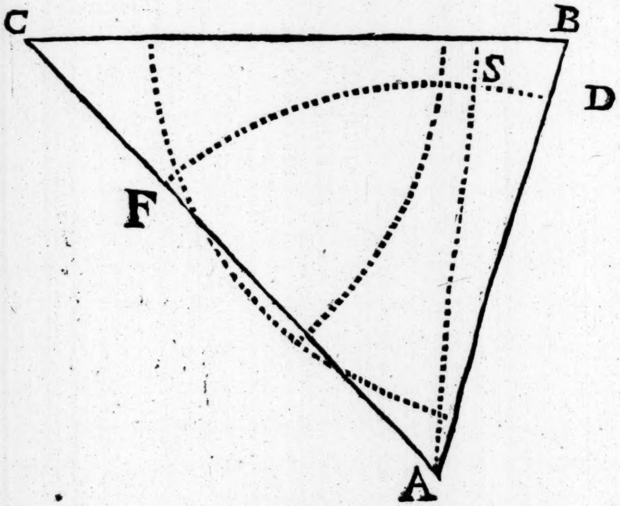
The like is to be underſtood of any other Queſtion of this nature.

Two Sides and their contained Angle being given, to find the third Side and the other Angles.

QUESTION III.

Two Ships ſet from one Port, and make an Angle of 58 deg. *one ſailed* N b E, *and the other ſailed* N W 1 deg. 45 min. *Weſterly, the Eaſtermoſt Ship ſailed* 70 *miles and came to her Port: The Weſtermoſt Ship ſailed* 89 *miles, and came to her Port: I demand the Diſtance of theſe Ports aſunder, and how they bear one from the other?*

First draw the North and South line A S. Let A B repreſent the Port you ſet from: Then from A as a Center, deſcribe the Arch of 60 *deg.* F S D: From S to the Eaſtwards ſet off one point: for N b E the Eaſtermoſt Ships Courſe draw the line A D at length, and ſet the firſt Ships diſtance 70 miles upon it, which is A B, then from A draw a N W line 4 *deg.* 45 *min.* Weſterly, and ſet off the Weſtermoſt Ships diſtance run upon that, which is 89 miles, and it reacheth from A to C, draw the line C B from the ends of the other two ſides, which is the Diſtance between the Ports (for the ends of each Ships run mnſt be the Ports) then is A C B the Angle of the bearing of the Eaſtermoſt Port from the Weſtermoſt, or A B C the bearing of the Weſtermoſt Port from the Eaſtermoſt, C A is a S E line, 1 *deg.* 45 *min.* Eaſterly from C, ſee how many points are contained between the C B and C A, by the way that is ſhewed in the Queſtion before, or becauſe B A is N b E line (from B) you may find the Point of the Compaſs that B C runs upon from B, you need find it but one of theſe ways, and the oppoſite point muſt be the other, as I have ſhewed before, then take the length of the ſide CB, which is the diſtance of the Ports aſunder, I find their diſtance and bearing to be as followeth.



The Diſtance between the two Ports is CB 79 miles.

The Bearing of them is Eaſt 5 *deg.* 35 *min.* Northerly, or Weſt 5 *deg.* 35 *min.* Southerly.

By the Tables.

Here is given the Angle at A, 58 *deg.* 00 *min.* the ſide A B 70 miles, the ſide A C 89 miles, which is two ſides, and their contained Angle, and here is required A C B or A B C, and the ſide B C.

Firſt

Firſt For the Angles.

For all Queſtions of this nature, this Rule is beneficial, and will work your Queſtion. Note,

That in all plain Triangles, the Sum of two Sides are in ſuch proportion to their Difference, as the Tangent of the half Sum of their oppoſite Angles, is to the Tangent of an Angle, which Angle ſhall be the Difference between the half Sum, and the Angles: ſo that if it be added to the half Sum, it ſhall make the greater Angle; if it be ſubtracted, it ſhall make the leſſer.

I have ſaid ſomething of this Rule before, which makes me demonſtrate it no farther here.

Proportion.

As the Sum of A B *and* A C 159 *miles*		*comp. arith.*	6,79860
Is to their Difference	19 *miles*		2,27875
So is the Tan. of the half Sum of B *and* C 61 d. 0 m.			10,25624
To Tangent of an Angle	12 10		9,33359

This added to the half Sum makes the Angle at B 73 *d.* 10 *m.* ſubtracted, it makes the Angle at C 48 *deg.* 50 *min.* which is 4 points, and 3 *deg.* 50 *min.* then ſay I, if C A be a *S E* Courſe, 1 *deg.* 45 *min.* Eaſterly from C, 'tis certain that C B muſt be 4 points and 38 *deg.* 50 *min.* from it, which is Eaſt 5 *deg.* 35 *min.* Northerly, the bearing of the Eaſtermoſt Port from the Weſtermoſt.

To find the half Sum of the Angles, Note that the three Angles are 180 d. *therefore if one of them be known, ſubtract that from* 180 d. *and the Remainder muſt be the other two.*

Now for their Diſtance aſunder, C B.

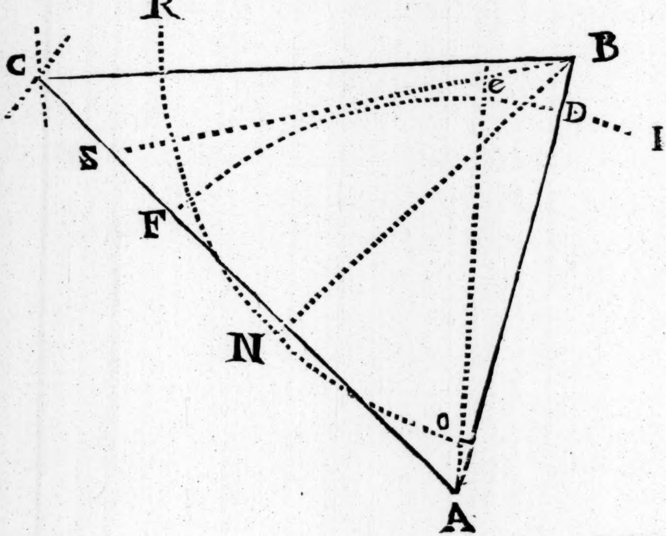
As Sine A C B 48 deg. 50 min.	*comp. arith.*	0,123321
Is to B A 70 mil.		2,845098
So is Sine B A C 58 deg. 00 min.		9,928420
To the Diſtance of the Ports aſunder C B 78 $\frac{8}{10}$		2,896839

The three Sides of a Triangle given, to find the Angles.

QUESTION IV.

Two Ships ſet from one Place, one ſails N b E *70 miles, the other ſails between the North and the Weſt 89 miles, and at the end of their ſailing they are diſtant aſunder 78 miles $\frac{2}{10}$ of a mile, I demand what Courſe the Weſtermoſt Ship ſailed, and how the two Ships bear one from the other?*

First draw the North and South line A e, make A the place of the Ships ſetting out, ſet off a N b E Courſe upon the Arch of 60 *deg.* I e, which is e D (becauſe the Eaſtermoſt Ship ſails N b E) likewiſe ſet off her Diſtance which ſhe ſailed upon that Courſe, which is A B 70 miles, then take the other Ships



Diſtance, which is 89 miles, and fixing one foot of your Compaſſes in A, with the other deſcribe the Arch at C: Laſtly, take the Diſtance of the two Ships aſunder 78 miles $\frac{2}{10}$, and fixing one foot of your Compaſſes in B, croſs that Arch, and from the place of interſection draw the ſides of the Triangle C A and C B: then meaſure the Angles from an Arch of 60 *deg.* as hath been ſhewed before; and to know them, conſider that A B is a N b E line, ſo that A F will be upon a Courſe ſo many points, or degrees, and minutes from a N b E, as there are points, or degrees and minutes in the Arch D F. Secondly, for the bearing of the Ships, which is the Angle at B: conſider that B A is a S bW line from B, and then the degrees and minutes, or points contained in the Arch O R, is ſo many degrees and minutes, or points from the S b W.

I have reſolved the Demands, which are as followeth.

The Courſe that the Weſtermoſt Ship ſteered was N W 2 *d.* Weſterly.

The bearing of the Eaſtermoſt Ship from the Weſtermoſt is W b S 5 *deg.* 30 *min.* Weſt.

I ſet the Angles by the plain Scale a little differing, becauſe the Scale cannot be gueſſed to a minute, or 2 or 5, nor the miles to a ſingle tenth.

By Proportion.

Here the three ſides are given us to find the Angles; the ſide A B is 70 miles, the ſide B C is 78 $\frac{2}{10}$ miles, the ſide C A is 89 miles.

A General Rule in Oblique Triangles.

As the true Baſe
Is to the Sum of the other two ſides:
So is the Difference of the ſides
To the alternate Baſe.

You may make which ſide you will the true Baſe. If you make either of the ſhorteſt ſides the true Baſe, and let fall a Perpendicular from the Angle oppoſite to it, the ſide muſt be extended in ſome caſes, for the Perpendicular will fall without the Triangle, and the extent of the alternate Baſe will fall as far without the Perpendicular, as the Perpendicular is without the length of the true Baſe: but if you make the longeſt ſide the true Baſe, the Perpendicular will fall within the Triangle in any Queſtion whatſoever, ſo that you will have no occaſion to extend the ſide, which makes me uſe the longeſt ſide for the true Baſe, though in this Queſtion take any ſide and it would fall within.

Here the ſide C A is longeſt, and therefore we will make that the true Baſe: take the length of the ſhorteſt ſide, which is A B, and fixing one foot of your Compaſſes in B, (the Angle oppoſite to the true Baſe) cut the true Baſe with that ſide B A in the point S, then draw the line S B which is equal to A B, the Perpendicular N B will fall in the middle between S and A, (which is in the point N) then ſhall S N, and N A be equal: C S is the alternate Baſe: ſay,

As C A *the true Baſe* 89 *miles*	*comp. arith*	7,0506699
Is to C B *and* A B 148 $\frac{9}{10}$ *miles*		3,1728947
So is their Difference 8 $\frac{9}{10}$ *miles*		1,9493900
To the alternate Baſe S C 14 $\frac{9}{10}$ *miles*		2,1728946

Subtract S C the alternate Baſe thus found	14 $\frac{9}{10}$
From C A the true Baſe 89 miles	89
And the Remainder is S A 74 $\frac{1}{10}$ miles	74 $\frac{1}{10}$
The half of which is N A 37 miles or	37 $\frac{1}{2}$ *tenth*

N A being thus found, I have A B beſides it in the right-angled Triangle A N B to find the Angle at A:

Say then,

As A B 70 *miles*	*comp. arith*	7,154901
Is to Radius		
So is A N 37 *miles*		2,568201
To Sine comp. NBA 58 deg. 6 min.		9,723102

Which is Sine B A C, *or the quantity of the Arch* D F.

Conſider then what Courſe the ſide A B runs upon, and 58 *deg.* 6 *min.* from that Courſe is the Courſe that the ſide A C runs upon.

Example.

A B runs upon a N b E Courſe from A: the ſide A C runs upon a Courſe 58 *deg.* 6 *min.* from it to the Northwards, and ſo to the Weſtwards, 58 *deg.* 6 *min.* is 5 points and 1 *deg.* 49 *min.* which is N W 1 *deg.* 45 *min.* Weſterly.

What this is above a Northweſt 1 *deg.* 45 *min.* Weſterly, is by the neglect of taking the abſolute Logarithm anſwering to 2,1728946; and alſo the neglect of the half tenth in dividing: you ſee it is but 6 *min.* of a degree of the Compaſs from the other, in the Queſtion before this, which is no ſenſible error in ſailing, and indeed I neglect working ſo near, to let any Learner ſee what a neceſſary thing it is to be exact: the Angle at A being thus found, you may find the other Angles at pleaſure, and alſo know what point the ſide B C runs upon, becauſe you know what point B A runs upon from B.

For the Angle C B A.

As C B $78\frac{2}{10}$ *miles*	*comp. arith.*	7,102922
To Sine B A C 58 d. 6 m.		9,928893
So is C A 89 *miles*		2,949390
To Sine C B A 73 d. 16 m.		9,981205

That is 6 points, and 5 *deg.* 46 *min.* more; then is B C a line that runs from B, W b S 5 *deg.* 46 *min.* Weſterly, or the Ship at C bears from the Ship at B, W b S 5 *deg.* 46 *min.* Weſterly.

Then muſt B bear from C, E b N 5 *deg.* 46 *min.* Eaſterly; and thus your deſire is known.

But you may think much, that a Fraction ſhould put you out ſo much as 6 *min.* (and if you know no better) you may be afraid it will cauſe ſome difference in the ſides; but if you examine this Example, you will find the ſides will not differ for this a full tenth of a mile.

Example.

By the Angles to find the ſides to agree with the ſides in the other Queſtion, within a tenth part of a mile.

As Sine B A C 58 deg. 6 min.	*comp. arith.*	0,07110
To C B $78\frac{2}{10}$		2,89707
So is Sine A B C 73 deg. 16 min.		9,98120
To C A $89\frac{0}{10}$ *miles*		2,94938

Here it is evident, that all this Difference doth not alter the ſides the tenth part of a mile.

If you deſire to ſee farther proof of the Rule, by which this Queſtion is wrought, you have a clear Geometrical Demonſtration for it in page 19 and 20 of my Fathers firſt Book of *Trigonometry*, which makes me forbear the demonſtrating of it by any Geometrical way.

Que-

QUESTION V.

Admit I be ſailing along the Shore, and ſee two Headlands, the Eaſtermoſt bears NNE *off me, the Weſtermoſt bears* NW *from me, at the ſame time I ſee an Iſland that bears South from me; but I ſail Weſt* 8 *miles, and find the Eaſtermoſt Head-land to bear* NEbE 5 deg. *Eaſterly from me, the Weſtermoſt* NNE, *and the Iſland* ESE: *I demand how theſe Places bear one from the other, and their Diſtance aſunder?*

SUch Queſtions as theſe are uſed in ſituating of places that are in ſight one of the other; or, as a man ſails by a land, he may take the Headlands bearing one from the other, and alſo the Imbays as well as the Head-lands, if he be not too far out.

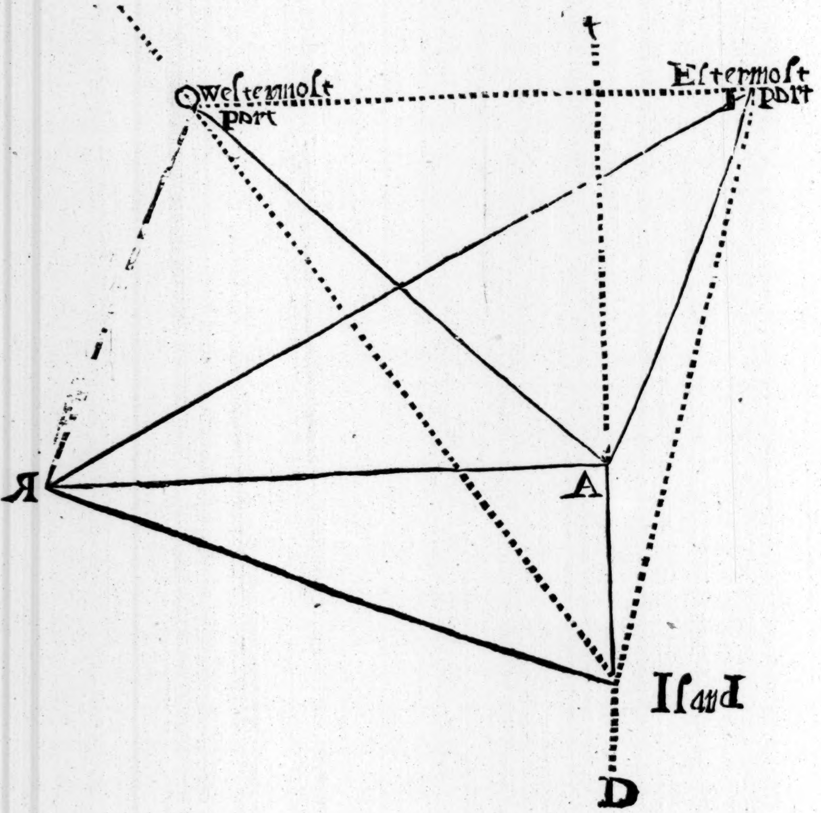
This Queſtion is wrought as the ſecond Queſtion, for here you have the bearing of the places you note in both Stations, and alſo the Courſe that you ſteer from one Station to the other, with the Diſtance; which is two Angles and a Side, to find the other two Sides, which is your Diſtance at each Station from the places.

For the protracting of this Queſtion; from your firſt Station draw a line upon thoſe ſeveral Courſes, as the Queſtion ſaith the places bear; As, ſuppoſe the firſt Station be A, from A draw A I a NNE line, and (mind) that line muſt be cut upon the Eaſtermoſt Head-land, becauſe the Queſtion ſaith it bears ſo.

Next draw a NW line from A, which is A C, and cuts the the Weſtermoſt Head-land.

Laſtly, draw out a South line from A, which is A D, and cuts the Iſland.

Then from A draw an Eaſt line (for the Courſe you ſteered) and ſet off 8 miles upon it, which is A R, from R draw a line to every place, as the Queſtion ſaith they bear; Then (namely) from R to the Eaſtermoſt Head-land, draw a N E b E line 5 *deg.* Eaſterly: from R to the Weſtermoſt Head-land draw a N N E line, and from R to the Iſland an E S E Courſe. Now becauſe the lines drawn from each Station cut the Head-lands and Iſland; it is evident that the



Point of their interſecting one another muſt be the places, (thus) A I and R I are the lines drawn upon the Courſe that lead from the Stations to the Eaſtermoſt Head-land, and cut in I, then is I the Headland. A O and R O are the Courſes that lead to the Weſtermoſt Head-land from both Stations, and interſect in O, therefore O is the Weſtermoſt Head-land.

Laſtly, A ſ and R ſ are the Courſes that lead from the two Stations to the Iſland; and therefore ſ is the Iſland, for there they cut.

Draw a line from every one of them as from ſ to O, and from O to I, from I to ſ, and take the diſtance of them aſunder; then for their bearing one from another, draw a North and South line from each place, and by an Arch of 60 *deg.* meaſure it, as hath been ſhewed.

By the Tables

Firſt, I conſider that I have the Diſtance between the two Stations, R A (which is a ſide of the triangles A R I, A R O, and A R ſ) and in every of theſe Triangles, the Queſtion gives me all the Angles, ſo that I can find my Diſtance from my Station to the Head-lands, after the form of this Example, which I ſhall do from each Station to the Eaſtermoſt.

For A I.

As Sine R I A 38 deg. 45 min.	*comp. arith.*	0,20347
To A R 8 *miles*		1,90309
So is Sine A R I 28 deg. 45 min.		9,68213
To A I 6 *miles* $\frac{2}{10}$		1,78869

For RI.

As RIA *Sine* 38 deg. 45 min.	*comp. arith.*	0,20347
To AR 8 *miles*		1,90309
So is RAI *Sine* (its comp. to 180 *d.*) 67 d. 30 m.		9,96561
To RI 11 *miles* $\frac{8}{10}$		2,07217

Here I have found the Diſtance from each Station to the Eaſtermoſt Head-land, next find the diſtance from the Weſtermoſt Head-land to the firſt Station AO.

For AO.

As Sine ROA 6 *points or* 67 d. 30 m.	*co. ar.*	0,034384
Is to RA 8 *miles*		1,903090
So is ORA 67 deg. 30 min. *Sine*		9,965615
To AO 8 *miles*		1,903090

Thus you might find RO, Rſ, and Aſ, for you have the ſame things given, namely, RA and the Angles: Here we have found the ſides AI and AO, and becauſe AI is upon a NNE Courſe, and AO upon a NW Courſe, the Angles contained between OAI muſt be 6 points or 67 *deg.* 30 *min.* ſo that we have two ſides and their contained Angle, to find the Angles of the bearing of theſe Head-lands AIO or AOI, and the Diſtance of them aſunder OI: this is wrought as the third Queſtion is. Thus, as this is found, ſo you may find the bearing of the reſt of the places one from the other, if there were twenty of them, for you have as much given in the other Triangles; but I leave it to your own practice alſo to make ſuch Experiments, or to frame ſuch Queſtions.

Two Sides and a contained Angle being given, to find the third Side and the Courſe (that each Side runs upon) provided that no Courſe be named, only the half of the Compaſs that you ſail in (or the quarter which is moſt commonly) and the Difference of Latitude that is made between the extent of the two Sides.

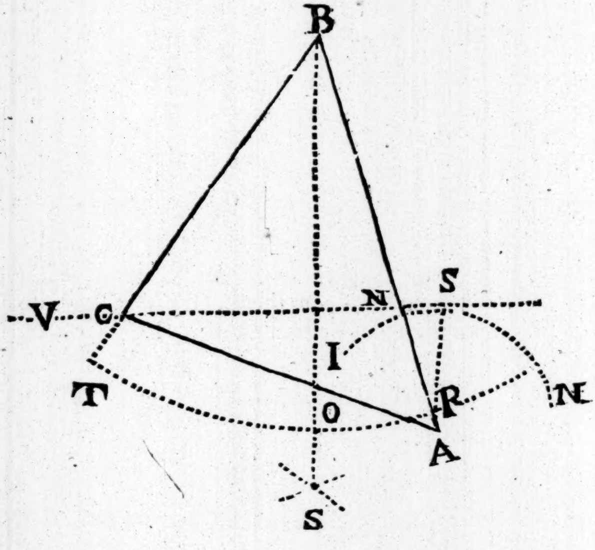
QUESTION VI.

Two Ships make an Angle of 50 deg. *the one ſails between the South and the Weſt* 40 *leagues, the other ſails between the South and the Eaſt* 50 *leagues, and at the end of their ſailing, the Eaſtermoſt Ship is more Southerly than the Weſtermoſt, ſo that they differ their Latitude* 15 *leagues; I demand each Ships Courſe, and their Diſtance aſunder.*

THe place the Ship ſet from, I make to be B, take off 60 *deg.* from your Scale, and deſcribe an Arch, making B your Center, as the Arch TR: then I take 50 *deg.* from my Scale, and ſet off ſomewhere upon that Arch, namely, from T to R, and from B, upon the Courſe that leads to T, I ſet off 40 leagues, my Weſtermoſt Ships Diſtance, and ſo conclude my Weſtermoſt Ship is at C: then from B upon the Courſe that leads to R, I ſet off my my Eaſtermoſt Ships Diſtance run, which is 50 leagues from B to A. Laſtly, draw A C, which is the Diſtance of the Ships at the end of their ſailing.

Then becauſe the Queſtion ſaith the Eaſtermoſt Ship was 15 leagues more Southerly in Latitude, than the Weſtermoſt; I will take 15 leagues from the Scale of equal parts, and fix one foot of my Compaſſes in A, and with the other deſcribe the Arch I S N, and draw the line from C, by the upper edge of the Circle at length, which muſt be an Eaſt and Weſt line, becauſe A is juſt 15 leagues to the Southwards of the neareſt part of it: then let fall a Perpendicular from B upon C N, and extend it as far as the Arch of 60 *deg.* which you firſt deſcribed T R, and it cuts in O, this muſt be a South line from B, namely B S; then meaſure upon the Arch of 60 *deg.* from O to R, for the Eaſtermoſt Ships Courſe, and from O to T for the Weſtermoſt Ships Courſe, as you do in any other Queſtion. I find them here as followeth,

The Eaſtermoſt Ship ſailed S b E 4. *d.* 40 *m.* Eaſterly.
The Weſtermoſt Ship ſailed S W 11 *deg.* Southerly.
The Diſtance aſunder is C A 39 leagues.



By Proportion.

Here are the two ſides B A 50 leagues, and B C 40, with the contained Angle C B A given, to find the Angles A C B and B A C; therefore for the Angles,

As

As B A *and* B C 90 *leagues*	*comp. arith.*	7,045757
Is to their Difference 10 *leagues*		2,000000
So is Tan. half the Angles B A C *and* B C A 65 d. 0 m.		10,331327
To Tang. their Difference 13 deg. 24 min.		9,377084

Which added to the half ſum 65 *deg.* is 78 *deg.* 24 *min.* the Angle A C B, ſubtracted from 65 *deg.* it makes 51 *deg.* 36 *min.* the Angle C A B.

Then for the Ships Diſtance aſunder, C A.

As Sine ACB 78 deg. 24 min.	*comp. arith.*	0,008962
Is to B A 50 *leagues*		2,698970
So is Sine C B A 50 deg. 0 min.		9,884254
To C A 39 deg. $\frac{1}{10}$ *leagues.*		2,592186

Here we have found the required Angles, and the required ſide, but we know not what point of the Compaſs either of the ſides that bounds the Triangles runs upon: but this which we have found makes way to it, for now we know the ſide A C to be 39 $\frac{1}{10}$ leagues; and if you let fall a Perpendicular from A, upon the Eaſt and Weſt line C N, it cuts it in S, then A S is known to be the Semidiameter of the Arch I N S u 15 leagues, ſo that in the Triangle A S C (right angled at S) we have A S 15 leagues given, and A C 39 $\frac{1}{10}$ leagues, to find A C S or C A S, we will find A C S.

As A C 39 $\frac{1}{10}$ *leagues*	7,407823
Is to Radius or A S C 90 deg.	
So is A S 15 *leagues*	2,176091
To Sine A C S 22 deg. 34 min.	9,583914

Here it is evident, the place A bears from the place C Eaſt 22 *deg.* 34 *min.* Southerly, which is E S E 4 minutes Southerly, becauſe C S is an Eaſt and Weſt line.

Alſo, if you ſubtract ACS 22 *deg.* 34 *min.* from ACB 78 *deg.* 24 *min.* the remainder will be BCS 55 *deg.* 50 *min.* the Angle that the Weſtermoſt Ship hath made from a Weſt Courſe Southerly (for that TCV and BCS are equal) ſo that I ſay, the Courſe that the Weſtermoſt Ship hath ſailed upon, is SW 10 *deg.* 50 *min.* Southerly, or the Courſe that leads to the place ſhe ſet from B, is NE 10 *deg.* 50 *min.* Northerly.

Then for the Eaſtermoſt Ships Courſe, conſider that BC is a SW Courſe 10 *deg.* 50 *min.* Southerly, and BA muſt be to the Southwards, and ſo to the Eaſtwards 50 *deg.* from it (which is 4 points and 5 *deg.*) that is, SbE 4 *deg*, 35 *min.* Eaſterly.

Two Sides of an oblique Triangle being given in one Sum, and the other Side alone, with an Angle oppoſite to one of the Sides, to find the Sides ſeveral, and the other Angles.

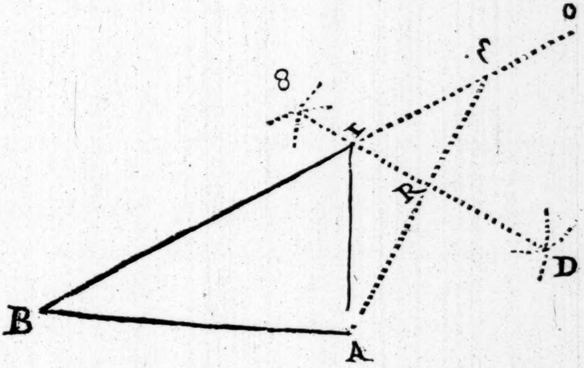
QUESTION VII.

Two Ships ſet from two ſeveral Ports, theſe Ports were both in one Parallel, and diſtant 92 miles, the Weſtermoſt Ship ſails NEbE, *the Eaſtermoſt Ship ſails upon ſome point between the North and the Weſt, and they both meet, if the Diſtance run of theſe Ships together be 159 miles: I demand them ſeveral, and the Eaſtermoſt Ships Courſe.*

LEt BA be the Parallel line the Ports be in. Let A be the Eaſtermoſt Port, B the Weſtermoſt, then muſt AB be 92 miles: from B ſet off a NEbE line, which is BCO, ſet off both the Ships runs upon it, which is 159 miles BC: then draw CA, which is the other ſide of the Triangle BCA, and divide it into two equal parts by a Perpendicular (as you ſee the Perpendicular DS doth, in the point R) draw this Perpendicular from one ſide of the Triangle to the other, as RI; then from I draw a line to A.

Then foraſmuch as A R is the half of A C or equal to R C, and I R is a Perpendicular to A C from R, I A and I C muſt be equal, and if B I C be the length of the two ſides 159, B I and I A are equal to them, ſo that B I is the Diſtance that the Weſtermoſt Ship ſailed, and I A is the Eaſtermoſt Ships run, meaſure them, and ſet them down; alſo I A B is the Angle from the Weſt toward the North, that the Eaſtermoſt Ship hath ſteered, I have found them to be as followeth.

The Eaſtermoſt Ship ſailed North 7 *d.* 20 *m.* Weſterly.
The Weſtermoſt Ship's Diſtance run is 102 *miles.*
The Eaſtermoſt Ship ſailed 57 *miles.*



By the Tables.

In the Triangle B A C I have the ſide B C given, 159 miles, the ſide B A 92 miles, and the contained Angle at B 23 *deg.* 30 *min.* whereby I may find the Angle at C, which we will do firſt.

As

As the Sum of BA *and* BC 251 *miles*	*comp. arith.*	6,600326
Is to their Difference 67 *miles*		2,816074
So is Tan. half BAC *and* BCA 73 d. 7 m.		10,517833
To Tan. their Difference 41 d. 20 m.		9,941

Which added to the half Sum, it makes BAC 114 *deg.* 27 *min.* the greater Angle: ſubtracted from the half Sum, it makes BCA 31 *deg.* 47 *min.* (which is equal to IAC, for if AI and IC, as alſo AR and RC be equal (as was proved before) and IR a Perpendicular to RA and RC, of neceſſity, the Angles in the Triangles IAR and ICR muſt be equal.

So that then, if from BAC	114 *d.*	27 *m.*
You ſubtract IAC equal to BCA	31	47
The Remainder is IAB	82	40

So that becauſe AB is a-Weſt line (from A) of neceſſity AI is a line that runs upon a Courſe 82 *deg.* 40 *min.* to the Northwards of it, which is North 7 *deg.* 20 *min.* Weſterly.

And thus we have the Angles and the ſide BA of the Triangle BIA to find the ſides AI and BI.

Firſt then for BI *the Eaſtermoſt Ship's run.*

As Sine BIA 63 deg. 35 min.	*comp. arith.*	0,047894
To BA 92 *miles*		2,963787
So is Sine BAI 82 deg. 40 min.		9,996433
To BI *the Eaſtermoſt Ship's run* 101 $\frac{9}{10}$ *miles*		3,008114

If you queſtion how the Angle BIA is known, it is eaſily reſolved; for if BAI be found, ABI was given, add them together, and ſubtract that from 180 *deg.* and the remainder muſt be BIA, becauſe the three Angles of any right lined Triangle is but 180 *deg.*

Laſtly, for I A *the Weſtermoſt Ships run.*

As Sine B I A 63 deg. 35 min.	*comp. arith.*	0,047894
To B A 92 *miles*		2,963787
So is Sine A B I 33 deg. 45 min.		9,744739
To I A *the Weſtermoſt Ships Diſtance run* 57 d. $\frac{1}{10}$ mil.		2,756420

I handled a Queſtion of this nature before, by which you may be directed: for though that be a right angled Triangle, and this an oblique angled Triangle, there is no difference in the demonſtration.

The three Sides of a Triangle being given in one intire Sum, and the Angles apart, to find the Sides apart.

QUESTION VIII.

Two Ships ſet from one place, one ſails S W, *the other ſails* S b W, *and at the end of their ſailing, they arrive at two ſeveral Ports; the Weſtermoſt of theſe Ports bears from the Eaſtermoſt* N W *and by* N: *Now if the Ships Diſtances which they ſail, with the Diſtance between the Ports be* 148 *leagues, (which is the three ſides of the Triangle) I demand the Diſtance that each Ship ſailed, and how far the Ports are aſunder?*

FOr the reſolving of this Queſtion, I will ſuppoſe the ſide that the Weſtermoſt Ship ſails upon to be 30 leagues, and ſo imagine you have the three Angles and a Side given, as you have in *Queſt.* 2. We will protract this after the directions there given, it being ſo laid down: I find by the Plain Scale, that theſe ſides are as followeth:

The ſide C N is given to be 30 leagues.
The ſide N B is found to be 42 leagues.
The ſide C B is found to be 24 leagues.

By the Tables the Proportion is,

As Sine B 45 deg.	0,15051
To C N 30 *leagues*	2,47712
So Sine N 33 d. 45 m.	9,74473
To C B 2 $\frac{6}{10}$ *leagues*	2,37236

For N B.

As Sine B 45 deg.	0,15051
To C N 30 *leagues*	2,47712
So Sine C (*take its Comp. to* 180 d.) 78 d. 45 m.	9,99157
To B N 41 $\frac{6}{10}$ *leagues*	2,61921

Theſe ſides with the ſide C N (added together) makes 95 leagues $\frac{2}{10}$.

Then it ſtands to good reaſon, that being the Angles in this Triangle are the ſame with the Angles in the Queſtion; therefore, as the ſum of theſe ſides are in proportion to the Sum of the ſides there, ſo is the ſum of the ſide 30 here, to the ſum of the ſide that is correſpondent to it there, or runs upon the ſame Courſe.

To find the Ships Diſtance that ſailed S W, *correſpondent to* C N 30 *leagues.*

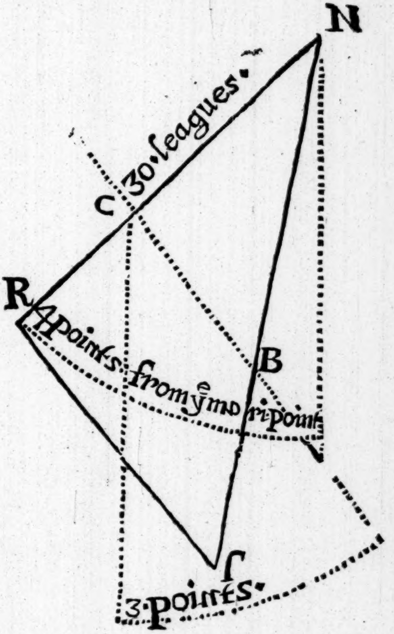
As ſum of the ſides of the Triangle C N B 95 *le. co. ar.*	7,021363
Is to the ſum of the ſides in the Queſt. 148 *leagues*	3,170261
So is the ſide C N 30 *leagues*	2,477121
To the Ships Diſtance that ſailed S W 46 *leagues* $\frac{6}{10}$	2,668745

Now we have the three Angles of the Triangle and a Side, ſo that we may lay it down by the Plain Scale, or work it by the Tables, as we wrought here in this Queſtion before: you might have wrought this proportion by the Rule of Three as well, or Geometrically, as I have ſhewed an Example of this nature there.

This ſide being thus found, we (to abbreviate the work) will lay it down in the Triangle before, whoſe Angles are equal to to the Angles here: ſet $46\frac{6}{10}$ leagues, for the length of the ſide, the Weſtermoſt Ships run, which is N R.

Draw R ſ parallel to C B, and extend N B till it interſect R ſ, which it doth in ſ.

This is as much as protracting of it anew, for the Angles at R, at ſ, and at N, are the ſame that they were given to be in the Queſtion, and the ſide R N 47 leagues, as it was found.



You may meaſure the ſides unknown by the Plain Scale, and ſet them down if you will, or you may work by the Rule of Three, uſing this Proportion.

As N C 30 *leagues is to* N R $46\frac{6}{10}$ *leag. So is* N B $41\frac{6}{10}$ *to* N S.

Multiply and divide, and it maketh $64\frac{6}{10}$ leagues, $\frac{14}{17}$ of a Tenth.

By the Tables for N ſ.

As N C 30 *leagues*	*comp. arith.*	7,52287
To N R 46 $\frac{6}{10}$ *leagues*		2,66839
So is N B 41 $\frac{6}{10}$		2,61909
To N ſ. 64 $\frac{6}{10}$ *leagues*		2,81035

We might have done this by the Tables, putting the Angles and Sides in proportion, as we have done all along in the other Triangles. But I ſuppoſe your own reaſon will give you, that this hath the ſame given in it that the Angle C N B had; and is wrought ſo.

The Fractions here, and the other agree, only this is not ſo true altogether, becauſe here we do it but to tenths, there in ſmaller Fractions, but this is within a ſmall part of one tenth of a unite.

For the Side R ſ.

As Sine N ſ R 45 deg. 00 min.	*comp. arith.*	0,15051
Is to R N 46 *leagues* $\frac{6}{10}$		2,66839
So is Sine N 33 deg. 45 min.		9,74473
To R ſ. 36 $\frac{6}{10}$ *leagues*		2,56363

If you add the ſides now found all together, it will come to $\frac{2}{10}$ of a unite leſs than the given ſides together, in the Queſtion is; now that ariſeth by neglecting the taking of the abſolute number, anſwering to the Logarithm that comes out; but this is ſufficient in caſes of this kind. If you had ſet it in paces, and wrought to the tenth part, you would have been out but $\frac{2}{10}$ of a pace, therefore uſe your mind in ſuch caſes. If you had wrought to Centiſms, you would have been nearer: but this I count near enough for ſailing, and I am ſure is more proper to be uſed, than ſuch ſmall Fractions, becauſe no long diſtances can be gueſſed to a mile or a league. You might have wrought your laſt proportion by the Rule of Three, as you did the other.

Three Sides of a Triangle given, to find the Center.

QUESTION IX.

There be three Ships bound to one place, the Eaſtermoſt is diſtant from the middlemoſt 40 *leagues, and bears* S E b E, *the middlemoſt is diſtant from the Weſtermoſt* 50 *leagues, and bears* N E; *now they every one know as much as I have writ, they alſo know they are of a like diſtance from this Port. I deſire to know what diſtance the Port is from them, and how it bears from each Ship?*

I Have applied this Queſtion to ſailing here, but before in this Book I have uſed it in a thing which is very proper for it; and indeed it may be of uſe many times, which makes me give it place here. I ſhall ſay nothing of this Queſtion by the Plain Scale, for it is done, as before you ſee: but we will do it by the Tables of Tangents and Logarithms.

Here I have given the ſide M er 40 leagues, the ſide M W 50 leagues, and the Angle at M, namely, its Complement to 180 *deg.* R M er 78 *deg.* 45 *min.* to find the Angles M er W and M W er:

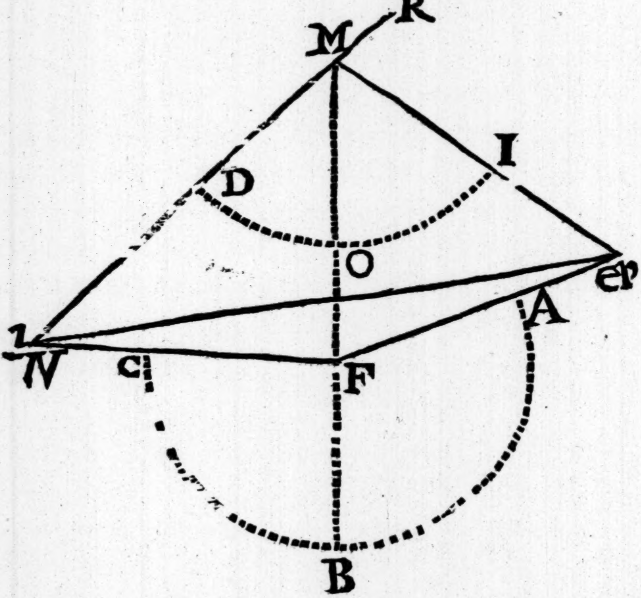
As W M *add* M er 90 *leagues*	*comp. arith.*	7,04575
Is to their Difference 10 *leagues*		2,
So is the Tan. of ½ M er W *and* M W er 39 d. 22 m.		9,91404
To Tan. of their Difference 5 deg. 12 min.		8,95980

Subtracted from 39 *deg.* 22 *min.* and the Remainder is M W er 34 *deg.* 50 *min.* added to it makes M er W 44 *deg.* 34 *min.*

For the Side er W.

As Sine M er W 44 deg. 34 min.	*comp. arith.*	0,153824
To W M 50 *leagues*		2,698970
So is Sine R M er 78 d. 45 m. *its comp. log.* 180 d.		9,991573
To W er $69\frac{9}{10}$ *leagues*		2,844367

But now you will demand of me, how we ſhall find any thing in the Triangle W F er, being there is but one thing known in it, namely, the Diſtance of the Eaſtermoſt Ship from the Weſtermoſt er W, I'll tell you.



Mr. Euclid *proves this, which makes me forbear it.*

Mr. *Euclid* (Book 3. Prop. 20.) ſaith, That in a Circle an Angle at the Center is double to an Angle at the Circumference, (provided) that both the Angles have to their Baſe one and the ſame part of the Circumference. The Center is F here, the Triangle W F er and W M er have W er to both their Baſes: then muſt B F A be double to I M O, or C B A double to D M I (that is to the Arch I O D) ſo that if you double D O I, 101 *deg.* 15 *min.*

15 *min.* it makes C B A 202 *deg.* 30 *min.* that ſubtracted from a Circle 360 *deg.* leaves the Triangle W F er: It is evident then that W F er is double to R M I becauſe R M I is what I O D wants of a Semicircle, as W F er is what C B A wants of a whole Circle, which is double to it.

Example.

	deg.	*min.*
W M er is 101 *deg.* 30 *min.* doubled it is C B A	202	30
That ſubtracted from a Circle	360	00
The Remainder is W F er	157	30
And this ſubtracted from	180	00
The Remainder is F W er and F er W	22	30
(for the Angles of a right angled Triangle are 180 *d.*)		
The half of which is F W er or F er W	11	15

For they muſt be equal, becauſe the ſides oppoſite to them are equal, namely, F er and F W.

And thus we have the three Angles of the Triangle W F er, and the ſide W er to find F er or F W or F M, the diſtance of any of the Ships from the Port.

For the Diſtance of the Ships from the Port.

As Sine W F er 22 deg. 30 min.	*comp. arith*	0,417160
Is to W er $69\frac{9}{10}$ *leagues*		2,844477
So is Sine F W er 11 deg. 15 min.		9,290235
To any of the Ships Diſtances from the Port which I find to be $35\frac{6}{10}$ *leagues*		2,551872

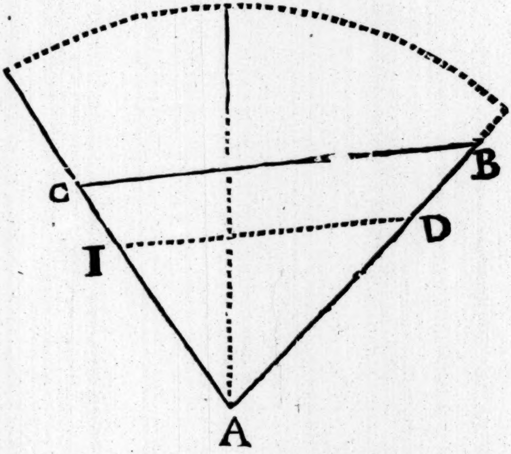
I need not count the Triangle (for the points) for I have ſhewed that ſufficiently: So that you, I ſuppoſe, can tell how to find the Ships bearing from the Port, for it differs nothing from the way you count in other Queſtions.

Que-

QUESTION X.

There was two Ships ſet from one Port, one ſailed N W b N *6 leagues a watch, the other ſailed* NE 8 *leagues a watch, theſe Ships arrived at two ſeveral Ports in one inſtant of time, the Ports were* 12 *leagues aſunder: I demand the Diſtance run of each Ship, and the Ports bearing one from the other?*

FOr the doing of this Queſtion, Firſt draw a N W b N line, and ſet off 6 leagues upon it which is A I; then draw a NE line, and ſet 8 leagues off upon it, which is A D; draw the ſide I D, then conſider that as A I is to A D, ſo is the Weſtermoſt Ships run to the Eaſtermoſt; ſo that the ſides A D and A I extended ſo far that a line of 12 leagues long, drawn parallel to D I, will juſt touch the extended ſides which muſt cut them in the places were the Ports are, namely, A B in B, and A I in C: meaſure the ſides C A and A B, and alſo the Angles of the Ports bearing A B C, or A C B and count them as hath been ſhewed before.



I find the ſide A B the Eaſtermoſt Ships run to be 10 *leag.* $\frac{7}{10}$. I find A C the Weſtermoſt Ships run to be 8 leagues. The Weſtermoſt port bears from the Eaſtermoſt Weſt, 4 *deg.* 14 *min.* Southerly.

By the Tables.

Firſt for the Ports bearing one from the other A D I equal to A B C, or A I D equal to A C B: they are equal, becauſe I D and C B are parallel, and I A D is an Angle oppoſite to them both.

As AD and AI 14 *leagues*	*comp. arith.*	6,853871
Is to their Difference 2 *leagues*		2,301030
So is Tan. ½ *AID and ADI* 50 *deg.* 37 *min.* 30 *ſec.*		10,085698
To Tan. their Diff. 9 *deg.* 51 *min.*		9,240599

Which added to the half Sum is A I D 60 *deg.* 28 *min.* A C B equal to A D I or A B C the bearing, ſubtracted from the half ſum is 40 *deg.* 46 *min.*

For I D.

As Sine D 40 *deg.* 46 *min.*	0,185100
To I A 6 *leagues*	0,778151
So is Sine IAD 78 *deg.* 45 *min.*	9,991573
To DI 9 *Leagues*	0,954824

For C A.		*For A B.*	
As I D 9 *leag. co. ar.*	8,04575	*As I D* 9 *leag. co. ar.*	8,04575
Is to C B 12 *leagues*	2,07918	*Is to C B* 12 *leagues*	2,07928
So is I A 6 *leagues*	1,77815	*So is A D* 8 *leagues*	1,90309
To A C 8 *leagues*	1,90309	*To A B* 10 $\frac{7}{10}$ *leagues.*	2,02802

The reaſon that the proportion ſtands thus, is becauſe the Angles are equal in each Triangle, and therefore the ſides muſt be proportional.

Thus the Eaſtermoſt Ship ſailed $10\frac{7}{10}$ leagues, the Weſtermoſt 8 leagues, and the Eaſtermoſt Port bears from the Weſtermoſt Eaſt 4 *deg.* 14 *min.* Northerly.

There is no Diſtance that a man ſails, but if he returns the ſame way that he went out, he ſhall find the ſame Diſtance backwards as he did out.

But now, the World is round; and if a man goeth out one way, and returns another (as it is common) he will find a great deal of difference in long runs. For to demonſtrate the reaſon of this I ſhall not, becauſe my Father and others have done that ſufficiently, beſides, it would take up too much room in this little Book.

Theſe Queſtions of Sailing may be underſtood in ſuch caſes as this is, namely, when a man ſails the ſame way home as he doth out: But becauſe the Winds will not ſuffer a man to do ſo, it is neceſſary to know ſome better way to ſail by, Let a man return never ſo contrary to what he ſailed outwards, yet at all times to know how near or how far he may be off.

Now there is no way better than *Mercator*'s way of Sailing, it is very excellent, and hath been treated of by many, and that makes me preſume to think that I may treat of it as well as others. And firſt here are the Tables of Meridional Parts, by which you are to work.

A
TABLE
OF
MERIDIONAL PARTS,
To every Third
MINUTE.

Latitud. *D.*	*M.*	*Mer. Parts*	*Latitud.* *D*	*M.*	*Mer. Parts*	*Latitud.* *D.*	*M.*	*Mer. Parts*
0	3	3	2	0	120	4	0	240
	6	6		3	123		3	243
	9	9		6	126		6	246
	12	12		9	129		9	249
	15	15		12	132		12	252
	18	18		15	135		15	255
	21	21		18	138		18	258
	24	24		21	141		21	262
	27	27		24	144		24	264
	30	30		27	147		27	267
	33	33		30	150		30	270
	36	36		33	153		33	273
	39	39		36	156		36	276
	42	42		39	159		39	279
	45	45		42	162		42	282
	48	48		45	165		45	285
	51	51		48	168		48	288
	54	54		51	171		51	291
	57	57		54	174		54	294
1	0	60		57	177		57	297
	3	63	3	0	180	5	0	300
	6	66		3	183		3	303
	9	69		6	186		6	306
	12	72		9	189		9	309
	15	75		12	192		12	312
	18	78		15	195		15	315
	21	81		18	198		18	318
	24	84		21	201		21	321
	27	87		24	204		24	324
	30	90		27	207		27	327
	33	93		30	210		30	330
	36	96		33	213		33	333
	39	99		36	216		36	337
	42	102		39	219		39	340
	45	105		42	222		42	343
	48	108		45	225		45	346
	51	111		48	228		48	349
	54	114		51	231		51	353
	57	117		54	234		54	355
2	0	120		57	237		57	358
			4	0	240	6	0	361

Latitud. *D.*	*M.*	*Mer. Parts*	*Latitud.* *D.*	*M.*	*Mer. Parts*	*Latitud.* *D.*	*M.*	*Mer. Parts*
6	0	361	8	0	482	10	0	603
	3	364		3	485		3	606
	6	367		6	488		6	609
	9	370		9	491		9	612
	12	373		12	494		12	615
	15	376		15	497		15	618
	18	379		18	500		18	621
	21	382		21	503		21	624
	24	385		24	506		24	627
	27	388		27	509		27	630
	30	391		30	512		30	634
	33	394		33	515		33	637
	36	397		36	518		36	640
	39	400		39	521		39	643
	42	403		42	524		42	646
	45	406		45	527		45	649
	48	409		48	530		48	652
	51	412		51	533		51	655
	54	415		54	536		54	658
	57	418		57	539		57	661
7	0	421	9	0	542	11	0	664
	3	424		3	545		3	667
	6	427		6	548		6	670
	9	430		9	551		9	673
	12	433		12	554		12	676
	15	436		15	557		15	679
	18	439		18	560		18	682
	21	442		21	563		21	685
	24	445		24	567		24	689
	27	448		27	569		27	692
	30	451		30	573		30	695
	33	454		33	576		33	698
	36	457		36	579		36	701
	39	460		39	582		39	704
	42	463		42	585		42	707
	45	466		45	588		45	710
	48	469		48	591		48	713
	51	472		51	594		51	716
	54	475		54	597		54	719
	57	478		57	600		57	722
8	0	482	10	0	603	12	0	725

Latitud. D.	M.	Mer. Parts	Latitud. D	M.	Mer. Parts	Latitud. D.	M.	Mer. Parts
12	0	725	14	0	848	16	0	973
	3	728		3	851		3	976
	6	731		6	855		6	979
	9	734		9	857		9	982
	12	738		12	861		12	985
	15	741		15	864		15	988
	18	744		18	867		18	991
	21	747		21	870		21	994
	24	750		24	873		24	998
	27	753		27	876		27	1001
	30	756		30	879		30	1004
	33	759		33	882		33	1007
	36	762		36	886		36	1010
	39	765		39	889		39	1013
	42	768		42	892		42	1016
	45	771		45	895		45	1019
	48	774		48	898		48	1023
	51	777		51	901		51	1026
	54	782		54	904		54	1029
	57	784		57	907		57	1032
13	0	787	15	0	910	17	0	1035
	3	790		3	913		3	1038
	6	793		6	917		6	1042
	9	796		9	920		9	1045
	12	799		12	923		12	1048
	15	802		15	926		15	1051
	18	805		18	929		18	1054
	21	808		21	932		21	1057
	24	811		24	935		24	1060
	27	814		27	938		27	1063
	30	818		30	942		30	1067
	33	821		33	945		33	1070
	36	824		36	948		36	1073
	39	827		39	951		39	1076
	42	830		42	954		42	1079
	45	833		45	957		45	1082
	48	836		48	960		48	1086
	51	839		51	963		51	1089
	54	842		54	966		54	1092
	57	845		57	969		57	1095
14	0	848	16	0	973	18	0	1098

Latitud.		Mer.	Latitud.		Mer.	Latitud.		Mer.
D.	M.	Parts	D.	M.	Parts	D.	M.	Parts
18	0	1098	20	0	1225	22	0	1354
	3	1101		3	1228		3	1357
	6	1104		6	1232		6	1360
	9	1107		9	1235		9	1363
	12	1111		12	1238		12	1367
	15	1114		15	1241		15	1370
	18	1117		18	1244		18	1373
	21	1120		21	1247		21	1376
	24	1123		24	1251		24	1380
	27	1126		27	1254		27	1383
	30	1130		30	1257		30	1386
	33	1133		33	1260		33	1389
	36	1136		36	1264		36	1393
	39	1139		39	1267		39	1396
	42	1142		42	1270		42	1399
	45	1145		45	1273		45	1402
	48	1149		48	1276		48	1406
	51	1152		51	1279		51	1409
	54	1155		54	1283		54	1412
	57	1158		57	1286		57	1415
19	0	1161	21	0	1289	23	0	1419
	3	1164		3	1292		3	1422
	6	1168		6	1296		6	1425
	9	1171		9	1299		9	1428
	12	1174		12	1302		12	1431
	15	1177		15	1305		15	1435
	18	1181		18	1308		18	1438
	21	1184		21	1311		21	1441
	24	1187		24	1315		24	1445
	27	1190		27	1318		27	1448
	30	1193		30	1321		30	1451
	33	1196		33	1324		33	1454
	36	1200		36	1328		36	1458
	39	1203		39	1331		39	1461
	42	1206		42	1334		42	1464
	45	1209		45	1337		45	1467
	48	1212		48	1341		48	1471
	51	1215		51	1344		51	1474
	54	1219		54	1347		54	1477
	57	1222		57	1350		57	1480
20	0	1225	22	0	1354	24	0	1484

Latitud.		Mer. Parts	Latitud.		Mer. Parts	Latitud.		Mer. Parts
D.	M.		D.	M.		D.	M.	
24	0	1484	26	0	1616	28	0	1751
	3	1487		3	1619		3	1754
	6	1491		6	1623		6	1758
	9	1494		9	1626		9	1761
	12	1497		12	1630		12	1765
	15	1500		15	1633		15	1768
	18	1504		18	1637		18	1772
	21	1507		21	1640		21	1775
	24	1510		24	1643		24	1778
	27	1513		27	1647		27	1781
	30	1517		30	1650		30	1785
	33	1520		33	1653		33	1788
	36	1524		36	1657		36	1792
	39	1527		39	1660		39	1795
	42	1530		42	1663		42	1799
	45	1533		45	1666		45	1802
	48	1537		48	1670		48	1806
	51	1540		51	1673		51	1809
	54	1543		54	1677		54	1813
	57	1546		57	1680		57	1816
25	0	1550	27	0	1684	29	0	1819
	3	1553		3	1687		3	1822
	6	1557		6	1690		6	1826
	9	1560		9	1693		9	1829
	12	1563		12	1697		12	1833
	15	1566		15	1700		15	1836
	18	1570		18	1704		18	1840
	21	1573		21	1707		21	1843
	24	1577		24	1710		24	1847
	27	1580		27	1713		27	1850
	30	1583		30	1717		30	1854
	33	1586		33	1720		33	1857
	36	1590		36	1724		36	1861
	39	1593		39	1727		39	1864
	42	1596		42	1731		42	1868
	45	1599		45	1734		45	1871
	48	1603		48	1738		48	1875
	51	1606		51	1741		51	1878
	54	1610		54	1744		54	1881
	57	1613		57	1747		57	1884
26	0	1616	28	0	1751	30	0	1888

Latitud. D.	M.	Mer. Parts	Latitud. D.	M.	Mer. Parts	Latitud. D.	M.	Mer. Parts
30	0	1888	32	0	2028	34	0	2171
	3	1891		3	2031		3	2175
	6	1895		6	2035		6	2179
	9	1898		9	2039		9	2182
	12	1902		12	2043		12	2186
	15	1905		15	2046		15	2189
	18	1909		18	2050		18	2193
	21	1912		21	2053		21	2197
	24	1916		24	2057		24	2201
	27	1919		27	2060		27	2204
	30	1923		30	2064		30	2208
	33	1926		33	2067		33	2211
	36	1930		36	2071		36	2215
	39	1933		39	2074		39	2218
	42	1937		42	2078		42	2222
	45	1940		45	2081		45	2226
	48	1944		48	2085		48	2230
	51	1947		51	2088		51	2233
	54	1951		54	2092		54	2237
	57	1954		57	2096		57	2240
31	0	1958	33	0	2100	35	0	2244
	3	1961		3	2103		3	2248
	6	1965		6	2107		6	2252
	9	1968		9	2110		9	2255
	12	1972		12	2114		12	2259
	15	1975		15	2117		15	2262
	18	1979		18	2121		18	2266
	21	1982		21	2124		21	2270
	24	1986		24	2128		24	2274
	27	1989		27	2131		27	2277
	30	1993		30	2135		30	2281
	33	1996		33	2139		33	2284
	36	2000		36	2143		36	2288
	39	2003		39	2146		39	2292
	42	2007		42	2150		42	2296
	45	2010		45	2153		45	2299
	48	2014		48	2157		48	2303
	51	2017		51	2160		51	2307
	54	2021		54	2164		54	2311
	57	2024		57	2167		57	2314
32	0	2028	34	0	2171	36	0	2318

Latitud.		*Mer.*	*Latitud.*		*Mer.*	*Latitud.*		*Mer.*
D.	*M.*	*Parts*	*D.*	*M.*	*Parts*	*D.*	*M.*	*Parts*
36	0	2318	38	0	2468	40	0	2623
	3	2321		3	2472		3	2627
	6	2325		6	2476		6	2631
	9	2329		9	2480		9	2634
	12	2333		12	2484		12	2638
	15	2336		15	2487		15	2642
	18	2340		18	2491		18	2646
	21	2344		21	2495		21	2650
	24	2348		24	2499		24	2654
	27	2351		27	2503		27	2658
	30	2355		30	2507		30	2662
	33	2359		33	2510		33	2666
	36	2363		36	2514		36	2670
	39	2366		39	2518		39	2674
	42	2370		42	2522		42	2678
	45	2374		45	2526		45	2682
	48	2378		48	2530		48	2686
	51	2381		51	2533		51	2690
	54	2385		54	2537		54	2694
	57	2389		57	2541		57	2698
37	0	2393	39	0	2545	41	0	2700
	3	2396		3	2549		3	2706
	6	2400		6	2553		6	2710
	9	2404		9	2556		9	2714
	12	2408		12	2560		12	2718
	15	2411		15	2564		15	2722
	18	2415		18	2568		18	2726
	21	2419		21	2572		21	2730
	24	2423		24	2576		24	2734
	27	2426		27	2580		27	2738
	30	2430		30	2584		30	2742
	33	2434		33	2588		33	2746
	36	2438		36	2592		36	2750
	39	2442		39	2595		39	2754
	42	2446		42	2599		42	2758
	45	2449		45	2603		45	2762
	48	2453		48	2607		48	2766
	51	2457		51	2611		51	2770
	54	2461		54	2615		54	2774
	57	2464		57	2619		57	2778
38	0	2468	40	0	2623	42	0	2782

Latitud.		*Mer.*	*Latitud.*		*Mer.*	*Latitud.*		*Mer.*
D.	*M.*	*Parts*	*D.*	*M.*	*Parts*	*D.*	*M.*	*Parts*
42	0	2782	44	0	2946	46	0	3116
	3	2786		3	2950		3	3120
	6	2790		6	2954		6	3124
	9	2794		9	2958		9	3128
	12	2798		12	2963		12	3133
	15	2802		15	2967		15	3137
	18	2806		18	2971		18	3142
	21	2810		21	2975		21	3146
	24	2814		24	2979		24	3150
	27	2818		27	2983		27	3154
	30	2822		30	2988		30	3159
	33	2826		33	2992		33	3163
	36	2830		36	2996		36	3168
	39	2834		39	3000		39	3172
	42	2839		42	3005		42	3176
	45	2843		45	3009		45	3180
	48	2847		48	3013		48	3185
	51	2851		51	3017		51	3189
	54	2855		54	3022		54	3194
	57	2859		57	3026		57	3198
43	0	2863	45	0	3030	47	0	3203
	3	2867		3	3034		3	3207
	6	2871		6	3039		6	3212
	9	2875		9	3043		9	3216
	12	2880		12	3047		12	3220
	15	2884		15	3051		15	3224
	18	2888		18	3056		18	3229
	21	2892		21	3060		21	3233
	24	2896		24	3064		24	3238
	27	2900		27	3068		27	3242
	30	2904		30	3073		30	3247
	33	2908		33	3077		33	3251
	36	2913		36	3081		36	3256
	39	2917		39	3085		39	3260
	42	2921		42	3090		42	3265
	45	2925		45	3094		45	3269
	48	2929		48	3098		48	3274
	51	2933		51	3102		51	3278
	54	2938		54	3107		54	3280
	57	2942		57	3111		57	3287
44	0	2946	46	0	3116	48	0	3292

Latitud.		Mer.	Latitud.		Mer.	Latitud.		Mer.
D.	M.	Parts	D.	M.	Parts	D.	M.	Parts
48	0	3292	50	0	3475	52	0	3665
	3	3296		3	3479		3	3670
	6	3301		6	3484		6	3675
	9	3305		9	3488		9	3680
	12	3310		12	3493		12	3685
	15	3314		15	3498		15	3690
	18	3319		18	3503		18	3695
	21	3323		21	3507		21	3700
	24	3328		24	3512		24	3705
	27	3332		27	3517		27	3709
	30	3337		30	3522		30	3714
	33	3341		33	3526		33	3719
	36	3346		36	3531		36	3724
	39	3350		39	3535		39	3729
	42	3355		42	3540		42	3734
	45	3359		45	3545		45	3739
	48	3364		48	3550		48	3744
	51	3368		51	3554		51	3749
	54	3373		54	3559		54	3754
	57	3377		57	3564		57	3759
49	0	3382	51	0	3569	53	0	3764
	3	3386		3	3573		3	3769
	6	3391		6	3578		6	3774
	9	3396		9	3583		9	3779
	12	3401		12	3588		12	3784
	15	3405		15	3593		15	3789
	18	3410		18	3598		18	3794
	21	3414		21	3602		21	3799
	24	3419		24	3607		24	3804
	27	3423		27	3612		27	3809
	30	3428		30	3617		30	3814
	33	3432		33	3622		33	3819
	36	3437		36	3627		36	3824
	39	3442		39	3631		39	3829
	42	3447		42	3636		42	3834
	45	3451		45	3641		45	3839
	48	3456		48	3646		48	3844
	51	3460		51	3651		51	3849
	54	3465		54	3656		54	3855
	57	3470		57	3660		57	3860
50	0	3475	52	0	3665	54	0	3865

Latitud. D.	M.	Mer. Parts	Latitud. D.	M.	Mer. Parts	Latitud. D.	M.	Mer. Parts
54	0	3865	56	0	4074	58	0	4295
	3	3870		3	4079		3	4300
	6	3875		6	4085		6	4306
	9	3880		9	4090		9	4311
	12	3885		12	4096		12	4317
	15	3890		15	4101		15	4323
	18	3896		18	4106		18	4329
	21	3901		21	4111		21	4334
	24	3906		24	4117		24	4340
	27	3911		27	4122		27	4346
	30	3916		30	4128		30	4352
	33	3921		33	4133		33	4357
	36	3927		36	4139		36	4363
	39	3932		39	4144		39	4369
	42	3937		42	4150		42	4375
	45	3942		45	4155		45	4380
	48	3947		48	4161		48	4386
	51	3952		51	4166		51	4392
	54	3958		54	4172		54	4398
	57	3963		57	4177		57	4403
55	0	3968	57	0	4183	59	0	4409
	3	3973		3	4188		3	4415
	6	3979		6	4194		6	4421
	9	3984		9	4199		9	4427
	12	3989		12	4205		12	4433
	15	3994		15	4210		15	4439
	18	4000		18	4216		18	4445
	21	4005		21	4221		21	4450
	24	4010		24	4227		24	4456
	27	4015		27	4232		27	4462
	30	4021		30	4238		30	4468
	33	4026		33	4244		33	4474
	36	4031		36	4250		36	4480
	39	4036		39	4255		39	4486
	42	4042		42	4261		42	4492
	45	4047		45	4266		45	4498
	48	4053		48	4272		48	4504
	51	4058		51	4277		51	4510
	54	4063		54	4283		54	4516
	57	4068		57	4289		57	4522
56	0	4074	58	0	4295	60	0	4528

A Declaration of the Table of MERIDIONAL PARTS.

THeſe Tables are in my Fathers Works to every ſix minutes, but here to every three minutes; ſo that if a man light not upon the very number that he deſireth, he may the eaſier take it, for it will be but one third or two thirds of the Difference between the two neareſt to be added or ſubtracted, I ſuppoſe it will be the leſs troubleſom; I have gone no farther than ſixty degrees, becauſe I would not take up too much room, and I ſuppoſe there is but little Trading to the Northwards of that Latitude, ſo that it would have been ſeldom in uſe. Theſe Tables were calculated by my Fathers Tables.

He that ſails according to *Mercator*'s Projection, notes the true Quantity of Longitude in degrees and minutes, namely, ſuch degrees as in that Parallel, 360 makes the Circumference. But they which ſail by *Plano*, meaſure the Sea, which is round, as though it were a flat or plain, now it ſtands to reaſon that there muſt be great Difference: as thus,

All North and South Courſes (which we call Meridians) interſect in the Poles: Now ſuppoſe there be two Ships under the Æquinoctial, 5 degrees or 100 leagues aſunder, and theſe Ships ſail both North, they will meet in the North Pole of the World, but by *Plano* they count them as far off there, as they were at firſt, for all North and South Lines are parallel one to another, as you may ſee in the Work all along.

Illuſtration.

All Meridian Lines (as I ſaid before) cut through the Poles of the World, and all Parallel Lines go round about the Poles, continuing the ſame diſtance from them. The Æquinoctial is one of theſe Parallel Lines, drawn equally diſtant from the Poles, and ſo is upon the body of the Earth; and there a degree of Longitude is 60 miles, and 360 times 60 miles is the Circumference of the Earth, which is 360 degrees.

But now if there be a drawn Parallel, 50 degrees nearer to one of the Poles, our own reaſon will give that that Circle will not contain ſo many miles round as the other did, becauſe it muſt be leſs; yet he that ſails by *Plano* counts that it doth, and though he hath Winds that carry him no better than due North from the Æquinoctial to the Parallel or Latitude of 50 degrees, he counts he hath as many Leagues from the Meridian of the Place he is bound to, as he had when he was under the Æquinoctial. Now tell me how it is poſſible, (if Meridians interſect in the Poles, as they do) that theſe Meridians ſhould be as far aſunder upon a Parallel of 50 degrees nearer the Poles, as they were under the Æquinoctial: I hope you underſtand me.

It is the work of *Mercator* to ſhew (therefore) the Quantity of a degree of Longitude in every Latitude, (for in theſe Parallels there is 360 degrees in the Circumference, but theſe degrees cannot contain ſo many miles as they do nearer the Æquator) It ſheweth how you may ſail upon any Courſe from one Latitude to another, and reckon your Longitude according to the truth of it in degrees and minutes: So that having two things given beſides the right Angle, you may find your deſire at Sea according to *Mercator*'s Direction, which is the ſureſt way of Sailing that I know, except Sailing by the Arch of a great Circle, and that and this will agree in degrees of Longitude, but that ſheweth the neareſt way to ſail from place to place, which is all that it differs from this, (they being both true) this ſheweth a general way of ſailing from place to place, that a particular way of ſailing the neareſt way from place to place: It is but ſeldom uſed, becauſe it is not very commonly known, but it is an excellent thing, I thought to have touched it, but I conſidered that my Father hath demonſtrated it as evidently as can be. For *Mercator* uſe the Tables here inſerted.

The Uſe of the foregoing Tables of Meridional Parts.

When you work this way, find firſt what Latitude you are in (if you cannot obſerve) do it by the things given that 24 hours: Then take notice what Latitude you were in the day before, and look in the Tables what anſwers to each Latitude, (ſetting them down) ſubtract the leſſer from the greater, and the remainder are the Meridional Parts contained between the two Latitudes, which number make for the length of the ſide, which contains the Difference of Latitude, and ſo work according to the Directions following: I will be brief.

Example. To find the Meridional Parts *anſwering to any Latitude.*

Let the one Latitude be 50 *deg.* 9′ in the Tables 3488 anſwers it.
Let the other Lat. be 47 *deg.* 48′ in the Tables 3274 anſwers it.
Subtract the leſſer from the greater, ——
and the Remainder is 214 the Meridional Parts contained in that Difference of Latitude.

The ſame is to be underſtood of any Latitude elſe.

QUESTION I.

The Latitude of two Places being given, and the Rumb, to find the Diſtance and Difference of Longitude.

Suppoſe I ſet ſail from a Place in the Latitude of 39 *deg.* 12 *min.* North Latitude, and am bound to a Place in the Latitude of 13 *deg.* 12 *min.* North Latitude, which bears S W by W from the other; I demand the Diſtance between thoſe Places, and Difference of Longitude.

Let A repreſent the Northermoſt place, C the Southermoſt, then is A and B the Latitudes of each place, CB the Difference of Longitude, BAC is the Courſe from the Northermoſt to the Southermoſt place.

For

For the Diſtance between the Places A C.

As Sine comp. A 56 deg. 15 min. *comp. arith* 0,25526
To AB *the Difference of Latitude in miles* 1560 3,19312
So is Radius

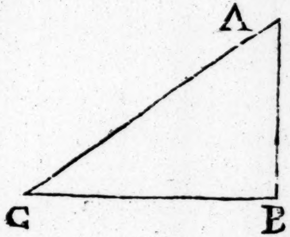
To the Diſtance between them C A 2808 *miles* 3,44838

For the Difference of Longitude.

The Meridional parts anſwering to 39 *deg.* 12 *min.* are 2560

The Meridional parts anſwering to 13 *deg.* 12 *min.* are 0799

The Meridional parts contained between the two Lat. 1761



As Radius
To B A 1761 *parts* 3,245759
So is Tan. the Rumb A 56 deg. 15 min. 10,175107

To C B *the Diff. of Longitude in minutes* 2635 m. 3,420866

The Quotient is the number of degrees and the Remainder is the number of minutes contained in the Difference of Longitude 43 *deg.* 55 *min.*

~~2~~(5
~~263~~(5(43
~~660~~

QUESTION II.

Courſe and Diſtance run, with one Latitude given, to find the other Latitude, and the Difference of Longitude.

SUppoſe I ſet from the Latitude of 49 *deg.* 9 *min.* North, and ſail S W b W 2808 miles. I demand the Latitude I ſhall then be in, and the Difference of Longitude.

Let A be the Latitude of 49 *deg.* 9 *min.* let A C be the Diſtance run 2808 miles, then is A B the Difference of Latitude, and C B the Difference of Longitude.

For the Difference of Latitude A B.

As Radius	
To C A 2808 *miles*	3,448397
So is Sine comp. 56 deg. 15 min. C A B	9,744739
To A B 1560 *miles*	3,193136
Which being divided by 60	

$$\begin{array}{l} \quad\;\cancel{3}(0 \\ \cancel{1}\cancel{5}\cancel{6}|0(26 \\ \quad\cancel{6}\cancel{6}\cancel{6} \end{array}$$

The Quotient and the Remainder is the Difference of Latitude in degrees and minutes, which is 26 *d.* 0 *m.*

That ſubtracted from 49 9

Leaves the Latitude you are now in 23 9

The reaſon why there is no inequality between degrees of Latitude, is becauſe all Meridians are great Circles, ſo that 60 miles is a degree of them always.

For the Difference of Longitude.

The Meridional parts contained between theſe two Latitudes I find to be

3396
1428
1968 *pts.*

As Radius	
To A B *in parts* 1968	3,294025
So is Tang. A *the Rumb* 56 deg. 15 min.	10,175107
To the Difference of Longitude 2945 m.	3,469133

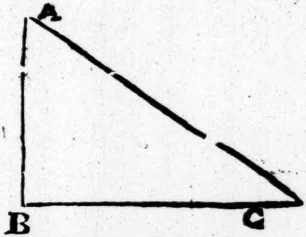
Now you may ask a reaſon why this Difference of Longitude ſhould differ from the other in the laſt Queſtion, ſeeing the Difference of Latitude, Courſe and Diſtance in each Queſtion are alike: the reaſon is, becauſe this Queſtion runs between two leſs parallels than the other did, and therefore the ſame things muſt give a greater part of this Parallel than it did of the other, though the number of miles of Departure be alike.

Divvide 2945 *min.* by 60, and you have the Difference of Longitude in degrees and minutes 49 *deg.* 5 *min.*

QUESTION III.

The Latitudes of two places, and the Diſtance between them given, to find the Courſe and Difference of Longitude.

Let one place (namely A) be in the Latitude of 49 *deg.* 9 *min.* North, let the other place (namely C) be in the Latitude of 23 *deg.* 0 *min.* North, and let the Courſe be between the South and the Eaſt, the Diſtance between them is A C 2808 miles.



For the Courſe A.

As AC *Diſt.*2808 *mil.* 6,551602
Is to Radius
So is the Diff.of Lat. AB *reduced into miles*, 1560 *miles* } 3,193124

To the Sine C, *whoſe Comp. is* A 9,744726
Which is 56 *deg.* 15 *min.* to the Eaſtwards of the South.

For the Difference of Longitude B C.

As Radius
To B A *in parts* 1968 3,294025
So is Tangent the Courſe A 56 deg. 15 min. 10,175107

To the Difference of Longitude in minutes 2945 3,469132
Which is as it was in the laſt Queſtion 49 *deg.* 5 *min.*

QUESTION IV.

The Latitude of two places, and their Difference of Longitude given, to find the Courſe and Diſtance, provided the Courſe be between the North and the Weſt.

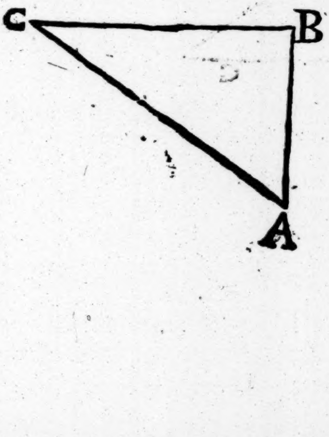
LEt the Latitudes be as before, and the Difference of Longitude 49 *deg.* 5 *min.* or 2945 parts or minutes.

For the Courſe.

As the Diff. of Latitude in parts AB 1968 *co. ar.*	6,70597
Is to Radius	
So is the Diff. of Longitude in minutes or parts BC 2945	3,46908
To the Tangent of the Courſe, A 56 deg. 15 min.	10,17505

To the Weſtwards of the North.

As Sine C 33 deg. 45 min. *comp. arith.*	0,25526
To the Difference of Latitude in miles AB 1560	3,19312
So is Radius	
To the Diſtance run CA 2808 *miles*	3,44839



QUESTION V.

The Difference of Longitude, Courſe, and one Latitude given, to find the other Latitude and the Diſtance in the Triangle CBA.

LEt CB be the Difference of Longitude 49 *deg.* 5 *min.* or 2945 *min.* A the Latitude of 23 *deg.* 9 *min.* North Latitude, CAB the Angle of the Courſe North-weſterly 56 *deg.* 15 *min.* let it be required to find AB the Difference of Latitude, (which added to the Latitude of A 23 *deg.* 9 *min.* will be the Latitude of the other place B) and AC the Diſtance between them.

Here you muſt find your Difference of Latitude in parts firſt, which will be reduced into miles (after the Latitude of the place at B is found) and then find your Diſtance 49 *deg.* 5 *min.* reduced into minutes (as I ſaid in the Queſtion) is 2945 *min.* the Difference of Longitude given.

For the Difference of Latitude in parts.

As Radius	
To the Difference of Longitude in parts 2945 *parts*	3,469085
So is Tan. comp. the Courſe A 56 deg. 15 min.	9,824897
To the Difference of Latitude in parts, 1968 *parts*	3,293977

This done I look in the Tables againſt the Latitude that is given me 23 *deg.* 9 *min.* and the Meridional part anſwering to

it, is	1428
To which I add the parts here found,	1968
becauſe the Latitude is increaſed,	
And there comes forth	3396

I look for that in the Tables, and I find anſwering to it the Latitude of 49 *deg.* 9 *min.* which is the Latitude of the unknown place B.

For the Diſtance between theſe Places.

I ſubtract the Latitude of A 23 *deg.* 9 *min.* from the Latitude of B (now found) 49 *deg.* 9 *min.* and the Remainder is the Difference of Latitude between them, 26 *deg.* 0 *min.* which converted into miles is 1560 miles: then ſay,

As Sine comp. 56 deg. 15 min. A *comp. arith.*	0,255260
Is to A B 1560 *miles*	3,193124
So is Radius	
To the Diſtance run A C 2808 *miles*	3,448384

I had thoughts to have ſhewed the Difference between *Plano* and *Mercator*, in an Example, but my Father hath done it in page 170 of his Book. If you are deſirous to know Great Circle Sailing, you may learn it from his Book, for he hath treated of it largely; and indeed it is the moſt neceſſary way of Sailing that is, for a man cuts his way much ſhorter (in many runs) than the uſual way that men go, doth: If you deſire to know in any Latitude the number of miles contained in any number of degrees of Longitude, convert your degrees and minutes of Longitude into minutes, and ſay,

As Radius
To Sine comp. that Latitude;
So is the Difference of Longitude in minutes
To the Difference of Longitude in miles.

If you deſire to convert miles of Departure (in any Parallel) into degrees, ſay,

As Sine comp. the Latitude or the Parallels diſt. from the Pole
Is to Radius;
So is the Departure in miles
To the Difference of Longitude in minutes.

Divide that by 60, and the Quotient with the Remainder is the degrees and minutes contained in that Departure.

Of the Longitude and Latitude of Places.

BEfore I come to ſhew how to keep a Reckoning by *Mercator*'s way, I will ſet down a Catalogue of the Latitude and Longitude of ſome Places in degrees and minutes, the Longitude taken from *Flowres* and *Corves*.

Places Names.		*Latitude*,		*Longitude.*	
		D.	*M.*	*D.*	*M.*
The *Taſſel*	North	53	00	35	10
The *Maze*	North	52	00	34	29
The *Willing*		51	30	33	53
Iſle of *Wight*		50	24	29	16
Dover		51	05	32	04
Portland		50	24	28	16
The *Start*		50	07	27	07
The *Lizard*		50	00	25	20
Silly		50	04	24	00
Uſhin		48	30	25	30
Cape *Finiſtre*		43	08	20	30
The Rock of *Lisbon*		38	52	20	47
Cape St. *Vincent*		37	00	21	29
Gilbraltar		36	01	24	39
Cape *Blanco*		20	32	13	09
Cape *de Verde*		14	31	13	10
Serrat Lion		08	00	17	53
South ſide of St. *Ann*		06	42	17	32
Cape *de Palmoſe*		04	00	24	30
Cape *Terras Pantas*		04	06	30	30
Cape *Formoſa*		04	04	39	15
River *Comrans*		03	19	42	32
Nethermoſt of the Iſle *Farmandoſa*		03	26	41	56
Middle of the Iſle of *Thoma*		00	00	40	00
Cape *de Lopez*		10	00	42	01

Cape

Places Names		Latitude.		Longitude.	
		D.	*M.*	*D.*	*M.*
Cape *Negro*	South	16	00	45	21
Cape *Boneſperanza*	South	34	25	52	30
North end of *Martinaſs*		23	02	17	16
Iſle of *Picos*		23	01	17	16
Iſle *Terreſtinam*		37	15	23	31
Y Digon Aluarum		38	54	26	45
Aſcenſion		08	21	20	16
St. *Ellna*		16	00	28	21
Cape *Agulhas*		35	00	54	00
Pomte Primere		32	25	63	06
Cape *Corentas*		24	00	69	50
Moſambique		15	10	75	32
Pemba		04	41	77	02
Cape *Derfue*		10	20	87	40
Cape *Guardafa*		12	01	87	41
Cape *de Raffas*		22	10	97	29
Serrat		21	01	108	35
Goa		15	40	109	22
Cape *Cormoram*		07	53	112	20
Point *Gada*		06	02	115	00
Northweſt Point of *Sumatra*		05	30	129	02
The Flat Point		05	51	137	26
Crequeta in *Sinda*		06	02	137	21
Eaſt end of St. *Brandon*		17	15	102	05
Eaſt end of *Diego Roderigos*		19	24	99	22
Southeaſt Harbor of *Maurice*		20	11	92	54
Southeaſt end of *Maſtorbos*		20	16	90	22
Cape *de Roman*		25	02	83	24
Iſle St. *Paulo*		38	30	108	40
Iſle St. *Maria Doguſto*		19	02	13	00
Aſſemaon		20	01	02	42
Eaſt end of the *Foul Ground*		18	21	00	00
Iſle *de Lobas* at *Rio de Plato*		35	25	343	02
Cape St. *Thoma*		22	21	358	01
Bay *Todas Sanctos*		13	15	357	41
Cape St. *Auguſtin*		08	41	001	12

Iſle

Places Names.		Latitude D.	Latitude M.	Longitude. D.	Longitude. M.
Iſle *Fernando*		03	45	005	14
Vizia		03	30	003	01
Venedo St. *Paulo*		01	52	006	25
The *Weſt*-Indies.					
Barbadoes	North	13	12	327	42
Ditiatha	North	16	18	326	32
St. *Chriſtophers*		17	20	324	52
Tobago		11	16	327	41
Eaſt ſide of *Trinidado*		11	37	326	41
Mattinino		14	48	325	30
St. *Vincent*		13	10	326	00
New point of *Portorica*		19	02	319	22
Altanalla near *Hiſpaniola*		17	26	313	52
Cape *Tibarune* in *Hiſpaniola*		18	14	310	22
Weſt end of *Margareta*		11	11	321	51
Cartagena		10	49	310	41
Iſland *Guanatho*		16	51	297	11
Weſt end of *Cuba*		22	00	298	44
Cape *Florida*		25	20	302	35
Bermuda Iſland the body of it		32	20	325	15
Iſland of *Sable*		43	40	334	02
Cape *Race* at *New-found-land*		46	32	339	32
Cape *Sable*		43	41	327	21
Cape *Cod*		41	20	322	01
Cape *Hattaraſs*		35	40	314	11
Cape *Henry*		37	00	344	00
Cape *Charles*		37	20	313	55
Weſt ſide of *CORVES*		40	00	000	00
Eaſt ſide of *FLOURES*		37	20	000	00
The Rode of *Fial*		38	50	002	17
Weſt end of *Fial*		38	41	002	48
Weſt end of St. *George*		39	00	003	00
Gratioſa		39	15	003	20

Places Names.		Latitude.		Longitude.	
		D.	M.	D.	M.
Weſt end of *Tercera*	North	39	00	03	40
Eaſt end of *Michael*	North	38	05	06	10
Eaſt end of *Maria*		37	00	06	01
Eaſt point of *Porto Santo*		33	05	15	26
Weſt end of *Madera*		32	20	13	48
Eaſt ſide of *Palma*		28	45	12	48
North point of *Gomera*		28	10	13	20
North ſide of *Ferro*		27	40	12	30
Northeaſt ſide of *Gammeſt*		28	36	14	31
Northeaſt point of grand *Canaria*		28	20	15	10
Eaſt end of *Fortaventure*		20	21	17	18
Eaſt end of *Lauſareta*		28	53	17	21
Eaſt end of *Gratioſa*		29	00	17	29
Eaſt end of St. *Antonio*		17	21	04	20
Eaſt end of St. *Vincent*		17	12	05	00
Eaſt point of St. *Lucia*		16	54	05	25
Eaſt point of *Sal*		16	54	07	30
Eaſt ſide of *Bonaviſta*		16	10	08	00
Eaſt ſide of the Iſle of *May*		15	00	07	30
Eaſt ſide of St. *Jago*		15	10	07	02
Fogo		14	36	06	00
Bramma Iſland		14	24	05	38

The Longitudes and Latitudess of theſe places here inſerted, are ſome of them my own Experiences, and the reſt Accounts of able men.

Concerning the foregoing Tables.

HE that is bound to any place, the firſt thing that he ought to conſider is the Latitude of each place, and the Difference of Longitude between them, which things may be taken from ſuch a Catalogue as this is, after the manner following.

Suppoſe I were bound from the *Lizard* to *Barbadoes*, I look in the Column of Latitude againſt the *Lizard*, and find 50 *deg.* 0 *min.* for its Latitude, and 25 *deg.* 20 *min.* for its Longitude, from *Floures* and *Corves*.

I look in the Column of Latitude againſt *Barbadoes*, and find 13 *deg.* 12 *min.* for its Latitude, and 327 *deg.* 42 *min.* for its Longitude from *Floures* and *Corves.*

Here you have the Latitude of each place; but to find the Difference of Longitude between theſe places, I conſider that *Barbadoes* hath 327 *deg.* 42 min. of Eaſt Longitude from theſe Iſlands; but if I ſubtract that from 360 *deg.* (the whole Circumference) there muſt remain the Weſt Longitude that is between them, which I find to be 32 *d* 18 *m*.

		Circumf.	360 00
To it add the longitude between the *Lizard* and *Floures* and *Corves*	25 *d.* 20 *m.*	Eaſt Long.	327 42
That Sum is	57 *d.* 38 *m.*		32 18

The Difference of Longitude between the *Lizard* and *Barbadoes* (the Meridian of *Barbadoes* being to the Weſtwards of the *Lizard* ſo many degrees.)

And thus any Difference of Longitude between two places is taken; provided, that one of them is nearer than 19 *deg.* to the Weſtwards of the place you begin your Longitude from, and the other nearer than 90 *deg.* to the Eaſtwards.

And the reaſon of this is, becauſe the Longitude of all places is ſet down from *Floures* and *Corves* to the Eaſtwards; ſo that if a place were but 1 *deg.* to the Weſtwards of *Floures* and *Corves*, it would be ſet down in the Catalogue to lie in the 359 *deg.* of Longitude.

For to know the Difference of Longitude between any two places, conſider which way they are neareſt, and that take: Suppoſe there were two places, one lieth in 20 *deg.* 0 *min.* of Longitude, the other lieth in 195 *deg.* of Longitude: I conſider that the difference between them is not 180 *deg.* and therefore I will ſubtract 20 *deg.* 0 *min.* from 195 *deg.* and the Remainder is the Difference of Longitude between them 175 *deg.* but if the Difference between two places be above 180 *deg.* as they are laid down in the Catalogue: Subtract that difference from 360 *deg.* and the Remainder is the neareſt Difference of Longitude: Your own reaſon will guide you in this, and therefore I will proceed.

How to keep a Reckoning of the Longitude and Latitude a Ship makes at Sea.

HAving found the Difference of Longitude between the places I ſet from, and am bound to, as alſo the Latitude of each place: I will begin my Reckoning thus:

Imagine it were between the *Lizard* and *Barbadoes*, and I ſet from the *Lizard* the 3$^{d.}$ of *January* 1658.

From the Lizard *we departed* January 3, 1658 *being bound to* Barbadoes, *lying in Latitude North* 13 d. 12 m. *Longitude*, *being Weſt from the Meridian of the* Lizard 57 d. 38 m.

	Mo. Day	Week Days.	Latitude.		Eaſt Long.		Weſt Long.	
			D.	M.	D.	M.	D.	M.
January	4	Friday	49	00	00	00	03	00
	5	Saturday	47	24	00	00	06	27
	6	Sunday	46	09	00	46	06	27
	7	Munday	45	00	01	05	06	27
	8	Tueſday	43	01	01	05	06	27
	9	Wedneſday	41	10	01	05	09	00
	10	Thurſday	40	00	01	05	11	02
	11	Friday	38	11	01	05	13	20
	12	Saturday	36	12	01	05	14	40
	13	Sunday	34	10	01	05	16	00
	14	Munday	32	20	01	05	18	47
	15	Tueſday	30	11	01	05	20	00
	16	Wedneſday	27	00	01	05	21	40
	17	Thurſday	25	01	01	05	22	30
	18	Friday	23	10	01	05	24	00
	19	Saturday	21	45	01	05	26	10
	20	Sunday	20	45	01	05	28	44
	21	Munday	19	00	01	05	31	00
	22	Tueſday	18	30	01	05	33	32
	23	Wedneſday	18	00	01	05	36	00
	24	Thurſday	17	27	01	05	38	20
	25	Friday	16	49	01	05	40	40
	26	Saturday	16	10	01	05	42	50
	27	Sunday	15	40	01	05	44	59
	28	Munday	15	00	01	05	47	00
	29	Tueſday	14	30	01	05	49	02
	30	Wedneſday	13	45	01	05	50	57
	31	Thurſday	13	12	01	05	52	00
February	1	Friday	13	14	01	05	54	30
	2	Saturday	13	12	01	05	54	40
	3	Sunday	13	12	01	05	54	40
	4	Munday	13	12	01	05	55	30
	5	Tueſday	13	12	01	05	57	30
	6	Wedneſday	13	12	01	05	58	35

Here in this Reckoning I have ſet down the Longitude in degrees and minutes, as before I ſet down the Departure in leagues, carrying all in the laſt line: the laſt line of my Reckoning ſaith, that they were in the Latitude of 13 *deg.* 12 *min.* and the whole Eaſt Longitude that we have made ſince we ſet from the *Lizard* is 1 *deg.* 5 *min.* the whole Weſt Longitude is 58 *deg.* 35 *min.* ſubtract the Eaſting from the Weſting, and the Remainder is 57 *deg.* 30 *min.* which lacks but 8 *min.* of 57 *deg.* 38 *min.* the Meridian of the Place.

Alſo the ſame line ſaith, that we are in the Latitude of 13 *deg.* 12 *min.* which is the Latitude of the place: therefore I conclude I am but 8 *min.* from it, ſo that I expect to ſee Land.

There is no Difference in the ſetting down of this Reckoning from that before, but only this is degrees and minutes, that leagues or miles; neither is there any other difference in their caſting up, for there your Eaſting from your Weſting in leagues, here in degrees.

That there be nothing wanting to make me be underſtood, I will here following do the three firſt days works in three Examples.

SUppoſe the firſt day I ſet out, I ſailed S W b W 6 *deg.* 25 *min.* Weſterly, till I come into the Latitude of 49 *deg.* 0 *min.* which was the next day at noon.

I conſider that I have the two Latitudes given me, and the Courſe to find the Difference of Longitude.

The Meridional part anſwering to 50 *deg.* 0 *min.* is	3475
The Meridional part anſwering to 49 *deg.* 0 *min.* is	3382
The Meridional parts contained between them is	93

For the Difference of Longitude.

As Radius	
To the Difference of Latitude in parts 93	1,96848
So is the Tangent of the Courſe 62 d. 40 m.	10,28661
To the Difference of Longitude in minutes 180	2,25510

This 180 divided by 60 produceth 3 *deg.* 0 *min.* the Difference of Longitude made that 24 hours; ſet it down in your Reckoning with the Latitude you were in, filling up the Eaſt Column with Ciphers: I need not ſhew how to find the Diſtance run, becauſe I ſuppoſe by what hath been ſaid before, you can do it.

For the ſecond days Work.

Suppoſe till the next day at noon we ſail S W 10 *deg.* 11 *min.* Weſterly, 169 miles by Eſtimation (for we could not obſerve.)

I conſider here that I have given the Courſe and Diſtance run and one Latitude, namely, the Latitude I was in yeſterday, 49 *deg.* 0 *min.* to find the Latitude I am now in, and my Difference of Longitude.

For the Latitude I am now in.

As Radius	
To the Diſtance run 169 *miles*	2,227886
So is Sine comp. the Courſe 55 d. 11 m.	9,756599
To the Difference of Latitude 96 *miles*	1,984486

This 96 miles is 1 *deg.* 36 *min.* which ſubtracted from the Latitude I was in yeſterday (becauſe the Courſe is Southerly) leaves the Latitude I am now in 47 *deg.* 24 *min.* (ſet it down in your Column of Latitude in your Reckoning) Thus I have both Latitudes and the Courſe, to find the Difference of Longitude.

I take the Meridional part anſwering to each Latitude, and ſubtract the one from the other, and there remains 144 parts.

For the Difference of Longitude.

As Radius	
To the Difference of Latitude in parts, 144 *parts*	2,158362
So is Tangent the Courſe 55 deg. 11 min.	10,157734
To the Difference of Longitude in minutes 207	2,316097

Which divided by 60, produceth 3 *deg.* 27 *min.* this I add to my weſt Longitude (becauſe the Courſe is Weſterly) 3 *deg.* 00 *min.* and it makes 6 *deg.* 27 *min.*

This 6 *deg.* 27 *min.* I ſet down in the Weſt Column, and thus you may keep your whole Longitude in the laſt line.

The third days Work.

Suppoſe the Winds be croſs, and that we are forced to tack, and we make our way good SSE, and I obſerve and find my ſelf in the Latitude of 46 *deg.* 9 *min.* I demand the Difference of Longitude.

I find the Meridional part anſwering to my Latitude yeſterday 47 *deg.* 24 *min.* is 3238

The Meridional part anſwering my Latitude gives this day by obſervation 46 *deg.* 9 *min.* is } 3128

The Meridional parts contained between theſe two Latitudes is } 110

As Radius

To 110 2,04139

So is Tangent 22 deg. 30 min. 9,61722

To the Difference of Longitude in minutes 46 m. 1,65862

This 46 *min.* is Eaſt Longitude, and muſt be ſet down in the Eaſt Column: and let the Weſt Column hold its Sum ſtill, as was done in the plain Reckoning before, and when you come to increaſe your Weſting again, carry your whole Eaſt Longitude along, and thus you have your whole Reckoning in the laſt line: The ſetting down of this differs nothing from the other; therefore to that I refer you.

Sometimes your Latitudes may be ſuch, that the Tables do not anſwer them to a minute, (for they are but to every 3 *min.*) as ſuppoſe the one Latitude were 13 *deg.* 20 *min.* the other 15 *deg.* 16 *min.* and I would take the Meridional part contained between them,

I look for 15 *deg.* 16 *min.* and cannot find it, but the neareſt leſs than it, is 15 *deg.* 15 *min.* againſt which I find 926
I look for the neareſt above it in the Tables, which is againſt 15 *deg* 18 *min.* and find } 929
——
I ſubtract the leſſer from the greater, the remainder is 003

Then I conſider that the difference between 15 *deg.* 15 *min.* and 15 *deg.* 18 *min.* is but 3, and that the portion that I want is but $\frac{1}{3}$ of this Difference, 1; therefore add 1 to the Meridional part anſwering to 15 *deg.* 15 *min.* which is 926, and it makes 927, the Meridional parts anſwering to 15 *deg.* 16 *min.* required.

The ſame I do for 13 *deg.* 20 *min.* and find the Meridional parts anſwering it to be 807, ſubtract them one from the other, and the remainder is the Meridional part contained between them; the like for any other, As

Suppoſe one demands of me the 20th. *day of* January, *how the Iſland of* Barbadoes *bears off me by my account in this Reckoning.*

I look upon my reckoning, and I find that day I was in the Latitude of 20 *d.* 45 *m.* and I have made Weſt Longitude 28 *d.* 44 *min.* Eaſt Longitude 1 *deg.* 5 *min.* I ſubtract the Eaſt Longitude 1 *deg.* 5 *min.* from the Weſt 28 *deg.* 44 *min.* there remains 27 *deg.* 39 *min.* the Weſt Longitude that I have made ſince I ſet from the *Lizard*; ſubtract this 27 *deg.* 39 *min.* from the Difference of Longitude between the *Lizard* and *Barbadoes* 57 *deg.* 38 *min.* and the remainder is 29 *deg.* 59 *min.* the Difference of Longitude which I have yet to make: I look at the top of my Reckoning for the Latitude of the place I am bound to, and find it to be 13 *deg.* 12 *min.*

57 *d.* 38 *m.*
27 39
————
29 59

Thus I have the two Latitudes, and the Difference of Longitude, to find the bearing of the place I am bound to: You may find it as is ſhewed before, *Queſt.* 4. by bringing your Difference of Longitude into minutes, and taking the Meridional parts contained between the Latitude you are now in, and the Latitude of *Barbadoes*; and uſing them as the ſides to work by.

If you have a mind to know your Diſtance (upon the Courſe) to *Barbadoes*, ſee what Difference of Latitude is between the Latitude you are in, and the Latitude of *Barbadoes*, reduce it into miles, and ſay,

As Sine comp. the Courſe
To the Difference of Latitude,
So is Radius
To the Diſtance.

And thus in brief you are able to give an account of your whole Reckoning at any time, or of any part of your Reckoning, if the day be given. The like you may do for the Courſe that was ſteered from day to day; but that (as I ſhewed before) ought to be taken notice of in a Journal, or if you like it better make a Column for it in your Reckoning. The reaſon why I refer that and the Winds and Variation, is, becauſe it can better be expreſſed with the reaſons of it than here.

Thoſe days that you obſerve, correct your Reckoning by your Obſervations, as my Father ſheweth in his practice after the Tables.

I had thoughts to have projected a Chart after the manner of *Mercator*, but becauſe few of them are made true, I forbear, and adviſe none to truſt them, except they are able to examine them.

If I have been too tedious either in this, or any thing elſe, remember this is but the buds of my beginnings, and hereafter I may learn to compriſe a great matter (more plainly) under fewer words, which is moſt docible.

Stars near the Æquinoctial, or declining 52 deg. *their Names and Declinations, with their Seaſons.*

		D.	M.	Seaſon
In the Girdle of *Andromeda*	North	33	52	July
In the Rams horn the firſt		17	36	Aug.
In the South foot of *Andromeda*		40	41	
In the Rams Head		21	51	
Perſeus right Shoulder		52	09	
Meduſa's Head		39	37	
Perſeus right ſide		48	33	
Bulls eye		15	46	Sept.
Orion's left foot	South	08	38	
Wagoners right foot	North	20	15	
Second in *Orion*'s Girdle	South	01	28	Oct.
Wagoners right Shoulder	North	44	51	
The great Dog in his mouth	South	16	15	
In the upper head of the Twins	North	32	34	Nov.
The leſſer Dog		06	03	
Hydra's Heart	South	07	14	
Lions Heart	North	13	35	Dec.
Lions Back		22	23	
Lions Neck		21	31	
Virgins Spike	South	09	21	Jan.
Arcturus	North	21	19	Feb.
South Balance	South	14	34	
North Balance		08	04	
The brighteſt in the Crown	North	27	54	
Scorpions Heart	South	25	34	Mar.
In *Ophiuch*'s right foot		20	30	
In the Harp the brighteſt	North	38	32	Apr.
Eagles heart *alias* Vultures		08	03	May.
Dolphins Tail		10	13	
Fomahant	South	31	20	June
In *Pegaſus* leg	North	26	16	
The Head of *Andromeda*		27	15	July

Stars near the North Pole, their Declination from it, with their Seaſons.

	D.	M.	*Seaſon*
North Star	02	29	July
In the hip of *Caſſiopeia*	31	06	
In *Caſſiopeia*'s knee	31	33	
In *Perſeus* right Shoulder	37	51	Aug.
In the great Bears ſide	31	49	Dec.
In the great Bears thigh	34	25	Jan.
In the great Bears rump	31	06	
Firſt in the great Bears tail	32	10	
Middlemoſt in her tail	33	17	
In the end of her tail	38	57	
In the bending of Dragons tail	24	01	Feb.
The formoſt Guard	14	22	
The hindmoſt Guard	16	42	
In Dragons head formoſt	37	25	Apr.
In *Cepheus* Girdle	20	52	June
In the back of *Caſſiopeia*'s Chair	32	42	July

A Table ſhewing how much the North Star *is above or beneath the* Pole, *for every ſeveral Poſition of the former or greater Guard,* Anno 1660 *complete.*

	The nether part of the Meridian accounted North.	*The upper part of the Meridian accounted North.*		Lat. 40		Lat. 60		
				d.	*m.*	*d.*	*m.*	
If the Guard bear from the North Star	S W b W	N W b W	*Then the North Star is*	0	13	0	16	*Beneath the Pole.*
	S W	N W		0	41	0	44	
	S W b S	N W b N		1	08	1	10	
	S S W	N N W		1	33	1	34	
	S b W	N b W		1	54	1	55	
	South	North		2	10	2	11	
	S b E	N b E		2	22	2	22	
	S S E	N N E		2	2[illegible]	2	28	
	S E b S	N E b N		2	29	2	29	
	S E	N E		2	24	2	24	
	S E b E	N E b E		2	15	2	15	
	E S E	E N E		1	59	1	00	
	E b S	E b N		1	39	1	41	
	Eaſt	Eaſt		1	16	1	18	
	E b N	E b S		0	50	0	53	
	E N E	E S E		0	22	0	24	
If the Guard bear from the North Star	N E b E	S E b E	*Then the North Star is*	0	08	0	05	*Above the Pole.*
	N E	S E		0	36	0	34	
	N E b N	S E b S		1	05	1	02	
	N N E	S S E		1	31	1	28	
	N b E	S b E		1	51	1	50	
	North	South		2	08	2	07	
	N b W	S b W		2	21	2	20	
	N N W	S S W		2	28	2	28	
	N W b N	S W b S		2	29	2	29	
	N W	S W		2	24	2	24	
	N W b W	S W b W		2	13	2	13	
	W N W	W S W		1	57	1	56	
	W b N	W b S		1	36	1	35	
	Weſt	Weſt		1	12	1	09	
	W b S	W b N		0	44	0	42	
	W S W	W N W		0	16	0	13	

Rules

Rules to find the Latitude, or Poles Elevation by the Meridian Altitude of the Sun or Stars, having the Tables of their Declination.

FIrſt, if the Sun or Star be on the Meridian to the Southwards, and have South Declination, add the Suns Declination to the Meridian Altitude, and it gives the Æquinoctial's height above the Horizon, that total ſubtracted from 90 *deg.* gives the Latitude Northerly, which is the Æquinoctials Diſtance below the Zenith or Poles Elevation.

Example.

Suppoſe upon the 11th. of *February*, 1663, I find the Suns

Declination to be Southerly	10 *d.*	22 *m.*
Suns Meridian Altitude I obſerve to be	30	10
That Total is	40	32
Which being ſubtracted from	89	60
The Remainder is the Poles Elevat. or Lat. North	49	28

If when you have added the Suns Declination to the Meridian Altitude, it exceed 90 *deg.* then caſt away 90 *deg.* and the Remainder is the Latitude Southerly.

Secondly, if the Sun or Star be on the Meridian to the Southwards, and have North Declination, ſubtract the Suns Declination from the Meridian Altitude, and it leaves the height of the Æquinoctial above the Horizon, that ſubtracted from 90 *deg.* leaves the Latitude Northerly.

Example.

Admit upon the 19th. of *May* 1663. the Suns Declination is Northerly	13 *d.*	17 *m.*
The Suns Meridian Altitude is	69	58
Suns Declination being ſubtracted the Remainder is	56	41
This ſubtracted from	89	60
Leaves the Latitude Northerly	33	19

Thirdly, if the Sun or Star be on the Meridian to the Northwards, and have North Declination, add the Suns Declination to the Meridian Altitude, and it gives the height of the Æquinoctial above the Horizon, that being taken from 90 *deg.* leaves the Latitude Southerly.

But if it exceed 90 *deg.* after the Declination is added, ſubtract 90 *deg.* from it, and the remainder is the Latitude: See in the firſt Rule an Example, in its operation as this is.

Fourthly, if the Sun or Star be to the Northwards and have South Declination, ſubtract the Suns Declination from the Meridian Altitude, and it gives the Æquinoctial's height above the Horizon; ſubtract that from 90 *deg.* and it leaves the Latitude Southerly.

Fifthly, if you obſerve when the Sun or Star hath no Declination, then the Complement of his Meridian Altitude is the Latitude.

Sixthly, if the Sun or Star be obſerved in the Zenith, the Declination is the Latitude.

If you have a deſire to work by the Complement of the Sun or Stars Meridian Altitude (which is uſed for its brevity by Seamen) do as followeth:

If the Sun hath South Declination, and be to the Southward of you, ſubtract the Suns Declination from the Complement of the Sun or Stars Meridian Altitude, and the Remainder is the Latitude Northerly: But if the Suns Declination be more than the Complement of the Suns Meridian Altitude, ſubtract the Complement of the Suns Altitude from the Declination, and the remainder is the Latitude Southerly.

Secondly, if the Sun or Star be on the Meridian to the Southwards, and have North Declination, add the Complement of its Altitude to the Declination, and the remainder is the Latitude.

If the Sun or Star be on the Meridian to the Northwards, and have North Declination, ſubtract the Declination from the Complement of the Meridian Altitude, and the remainder is the Latitude Southerly: If the Suns Declination be more than the Complement of the Sun or Stars Meridian Altitude, ſubtract the Altitude from the Declination, and the Remainder is the Latitude Northerly.

If the Sun or Star be to the Northwards, and have South Declination, add the Declination to the Complement of the Meridian Altitude, and the remainder is the Latitude Southerly.

If you obſerve the Sun when he hath no Declination, the Complement of his Meridian Altitude is the Latitude.

If you obſerve the Sun or Star in the Zenith, the Declination is the Latitude. And thus much for the finding the Latitude by the Suns Meridian Altitude, or the Complement thereof; alſo for ſuch Stars as have their Declination from the Æquinoctial.

For thoſe Stars whoſe Declination is their diſtance from the Pole, if you obſerve them under the Pole, add the Declination to the Meridian Altitude; if above the Pole, ſubtract their Declination, and the Remainder is the Latitude. And thus much for finding the Latitude by the Declination, and Meridian Altitude of the Sun or Stars, or the Complement of the Meridian Altitude of the Sun, or ſuch Stars whoſe Declination is their diſtance from the Æquator.

OF
ASTRONOMY.

I Had thoughts to have handled the Doctrine of Spherical Triangles fully, but if I ſhould, I might do that which my Father hath done before, better than I can; the thing which induced me to this thought was that I might make the Application of it to Great Circle ſailing; but becauſe that way of ſailing (though the beſt) is ſeldom uſed, I have not ſet it in my Book; if you deſire to know it, you may ſee the way of it in my Fathers works, as plainly as (I think) it can poſſibly be demonſtrated by any man.

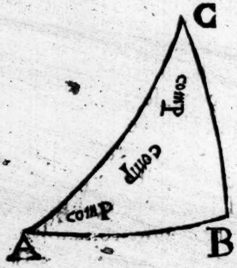
I have thought good to make uſe of his fundamental Axiom, to ſhew how to reſolve thoſe Queſtions in the Sphere, which I have wrought in this Book by the Plain Scale, though I confeſs (for Amplitudes of Riſing and Setting, and Azimuths at certain given hours, with divers other things that are chiefly to be minded at Sea, for the Variation of the Compaſs, and other neceſſary uſes), I hold the Plain Scale to be true enough, but that I conceive not to be ſo ſatisfactory to all men, and therefore I have done this, the Axiom is this:

The Sine of a middle part with Radius, is equal to the Tangents of the Extremes adjacent, or to the Sine Complement of the oppoſite Extremes.

Now for Brevities ſake it is common to uſe theſe Characters, for this Character ┼ ſignifieth with Radius or more, or one Side or Angle with an another, for equal =, for leſs — ; ſo that the general Rule or fundamental Obſervation which we purpoſe to uſe, may be expreſſed thus:

The Sine of the middle part ┼ Radius is = to the Tangents of the Extremes adjacent, or to the Sine complement of the oppoſite Extremes.

This Rule being rightly underſtood gives ſuch full directions, that a man may reſolve any Queſtion in the Sphere by it, which makes me judge thoſe culpable of a fault, that accuſe him of Prolixity, that made it in ſo brief a manner. I will define a ſpherical right angled Triangle, and ſo come to the uſe of this Axiom.



In the ſpherical right angled Triangle A B C, right angled at B, there are 5 things conſiderable, beſide the right Angle, namely, the three Sides and the two Angles; the two Sides next to the right Angle are not noted to be Complements, but the Side A C, the Angle A, and the Angle C, is noted by their Complements to a Quadrant (which are the three things fartheſt from the right Angle B.)

If you have two things given beſide the right Angle, to find a third (as you always have) the firſt thing that you are to conſider, is, whether it be an adjacent or an oppoſite Extreme.

That is an adjacent Extreme, when the given parts and the required part joyn.

For Example in Adjacent Extremes.

Suppoſe the given things were A C and A C B, and the required thing were C B: Here you ſee that A C is joyning to C, and ſo is C B, therefore they all joyn, and C is the middle part, for it is between B C and C A the Extremes.

That is an oppoſite Extreme that hath two things lying together, and the third thing lieth alone, and that part which lieth alone is the middle part.

Example.

Suppoſe the three things (namely the two given things, and the required thing) were B C, the Angle at A, and C A; then I conclude that C B is the middle part, and that it is an oppoſite Extreme, becauſe it is alone, and the other thing, namely, C A and A are together: If you ask how this can be, thus:

A C B is between C B and C A, and A B is between C B and the Angle at A, which proves that B C is alone, and A C and the Angle at A joyns: Then is A C and the Angle at A alſo the two Extremes.

Pray obſerve this for a Rule, that the right Angle never parts any thing, for if C B, the Side B A, and the Angle at A be the three things, it is nevertheleſs an adjacent Extreme; for though the right Angle be between the Sides B A, and B C, yet do not count that it parts them, (as another Angle would) ſo as to make it an oppoſite Extreme.

Or if the given and required things were the three Sides, you might judge B A the middle part, becauſe it is alone, for the Angle at A parts it from A C, and the right Angle at B is between B C and it: Now never count that the right Angle at B parts B C from B A, but that they lie together, and A C lies alone, being parted by the Angle C from C B, and by the Angle A from A B, and ſo is the middle part: Theſe be the firſt conſiderations (after you have a Queſtion ſet you) that you ought to mind, without regarding which of the three things is given or required.

We now come to apply this general Axiom. Suppoſe I have the Side B C given, the Angle at C, and that the Side C A be required.

From what hath been ſaid I know C to be the middle part and that it is an adjacent Extreme; I will apply the Rule thus, it ſaith the Sine of the middle part, which intimates that the middle part muſt be always ſo called, as you may take the Sine of it; now becauſe its noted to be a Complement, you muſt call it Sine Complement, to find the Sine of it. This done, I will go to one of the Extremes, and conſider what the Axiom ſaith for that, (admit it be the Extreme CB) It ſaith the Sine of the middle part with Radius, is equal to the Tangents of the Extremes adjacent; from whence I conclude, that I muſt call CB ſo, as that I may have the Tangent of it; Now CB is not noted to be a Complement, and therefore I call it Tangent CB: Laſtly, for the other Extreme CA, for the ſame reaſon I muſt call it ſo, as that I may take the Tangent of it: and becauſe it is noted to be a Complement, therefore I call it Tangent Complement, to have the Tangent of it: Now as I go along thus in my thoughts, I will ſet it down as I conſider it, and it frames this Rule:

Sine com. C + *Radius is* = *to Tang.* CB + *Tang. comp.* CA.

My Queſtion being brought into this order, I will conſider which is given and which is required: thoſe which are given, I will ſet down firſt, the thing required undermoſt, and look for them in the Tables by the directions which I have framed from the Axiom.

Look for	Sine comp. C
For	Tangent BA
Add them together, caſting away Radius, and the Sum look for in the Tangents	——— ——— take Tan. com. CA

it produceth your deſire.

And thus this Axiom ſets your buſineſs in order; but now that you may know when to take a Complement arithmetical, or let it alone; and alſo, that you may know which thing it is that you muſt take the Complement arithmetical of, obſerve this Rule, either in adjacent or oppoſite Extremes.

That if the middle part and an extreme be given, take the Complement arithmetical of the given Extreme; but if the two Extremes be given, to find the middle part, take no Complement arithmetical at all: This may be ſufficient for all Queſtions in right angled Triangles, will fall out one of theſe two ways; this Complement arithmetical is what every figure in the Tables wants of 9: it was firſt invented by my Father, it ſaves a labour of Subtracting, and ſo abbreviates the work much.

To many which I have taught, it hath ſeemed ſtrange that a thing is called Sine comp. or Tan. comp. (when one is to find the Sine or Tangent of it) but the reaſon of it is this; if a thing be a Complement already (as three things in every right angled ſpherical Triangle is noted to be) the comp. of that Complement muſt be the Sine or Tangent of that Complement.

But pray mind me; I have noted that there are five things in every right angled Triangle conſiderable, beſides the right Angle.

Now obſerve this for a Rule, (when you are framing your Rule from the general Axiom to work by) that if you call any of theſe five things by their names, you ſhall not have the Complements of them, but call any of them out of their names, and you ſhall; I mean thus. Suppoſe you have a mind to take the Sine of A B, it is noted not to be a Complement, therefore call it Sine A B, to have the Sine of it, or Tangent A B to have the Tangent of it, the like for C B.

Again, if you have a mind to take the Sine of C A, I conſider that C A is noted by the name of a Complement, call it Sine comp. ſo ſhall you have the Sine of it, or Tangent Complement, and you ſhall have the Tangent of it; the like for the two Angles contrariwiſe: If you have occaſion to take the Complements of them, call them out of their names.

Example in oppoſite Extremes.

Suppoſe A B be given, and B C, and the Side A C be required.

From what hath be ſaid, I conſider this is an oppoſite Extreme, and that A C is the middle part; (for that is alone) call A C Sine Complement to find the Sine of it: and becauſe the Axiom ſaith, that the Sine of the middle part with Radius, is = to the Sines Complement of the oppoſite Extremes (for the former Reaſons) call A B Sine comp. and B C Sine comp. which is out of their names, and you have this Rule:

Sine com. A C + *Radius is* = *to Sine com.* A B + *Sine com.* B C.

This done, ſet the things down by the order of this Rule, with the required thing under moſt thus:

Sine com. C B
Sine com. A B
———
Sine com. A C

Take the figures anſwering the number of degrees and minutes, which the given things may contain, (out of the Tables) add them together, caſting away Radius, (if it comes to be above it) and look for the Remainder amongſt the Sines, and take the Complement of that Sine that anſwers it, to anſwer your demand.

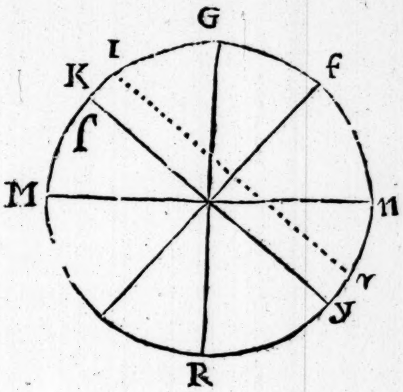
Suppoſe it were A B and A C that were given, to find the Angle at C; this is oppoſite Extreme, and A B is the middle part, call A B (the middle part) Sine, (which is by its name) to find the Sine of it, and A C, and the Angle at A out of their names (which is Sine A C, and Sine A) to find the Sine Complement of them, and thus for any elſe.

Be ſure to remember the Rule that I propounded about the Complement arithmetical, that ſo you may know when to take it, and when to let it alone. This is in brief.

My Father hath ſhewed the proportions that holds, and the reaſons of them, which I purpoſely omit, knowing that this Rule works thoſe Proportions: We will now come to the work it ſelf; and I ſhall do only thoſe Queſtions which I wrought by the Plain Scale, as being moſt neceſſary for our uſe that go to Sea.

Latitude 50 deg. 00 min. *Northerly*, *Declination* 13 deg. 15 m. *Northerly, I demand the Meridian Altitude of the Sun.*

LEt M G n R repreſent the Meridian, M n the Horizon, K y the Equinoctial, I ♈ the Parallel of the Suns Declination, G the Zenith, R the Nadir, ſubtract the Latitude G K 50 *deg.* 0 *min.* (= to n f) from G K M 90 *deg.* and the Remainder is K M, the height of the Æquinoctial above the Horizon, 40 *deg.* 0 *min.* to which add the Suns Declination K I 13 *deg.* 15 *min.* and the Sum is I M the thing required, 53 *deg.* 15 *min.* as you may ſee in this Example.



	50	00
	90	00
	40	00
This, if the Suns Declination be	13	15
Northerly	53	15

But if the Suns Declination were Southerly, namely, ſo as that her Parallel of Declination cut the Meridian in ſ; ſubtract the Suns Declination K ſ from the height of the Æquinoctial above the Horizon K M, and the Remainder is ſ M, the Suns Meridian Altitude.

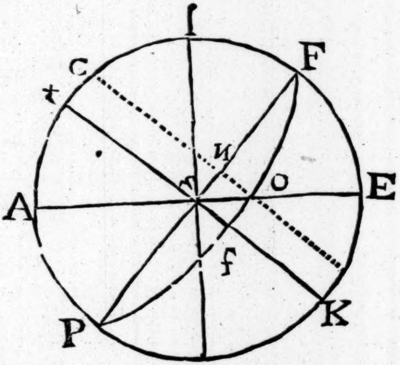
In any Latitude, ſubtract the Latitude from 90 *deg.* and ſo you have the Æquinoctials height above the Horizon; then ſee whether the Meridian Altitude be greater or leſſer than that; if greater, add the Suns Declination to the Æquinoctials height above the Horizon, if leſſer ſubtract it, and the Remainder is the Suns Meridian Altitude: and this is evident, becauſe the Suns Declination is his Diſtance from the Æquator, and ſo he can be but as much higher or lower than the Æquator, as his Declination is.

Latitude 50 deg. 0 min. *Declination* 13 deg. 15 min. *Northerly, I demand the Suns Amplitude of Riſing and Setting.*

NOte, that the ſides of a Spherical Triangle are three Arches of Great Circles, every Arch being leſs than a Semicircle; and therefore the Parallels or other leſſer Circles of the Sphere muſt not be taken as the Sides of a Triangle.

FOP is an Arch of the Meridian, cutting the Center of the Sun at his Riſing, which is at O (you have been told that all Meridians cut the Æquinoctial at right Angles) then muſt o ſ ♈ be a right Angle, and in it I have given ſ o the Suns Declination (= to t c) and ſ ♈ o = 40 *deg.* 0 *min.* the meaſure of f ♈ o, is E K = to t A the Complement of t ſ to 90 *deg.* (t ſ being the Latitude 50 *deg.* 0 *min.*) and I am to find ♈ o, the Suns Amplitude of Riſing; I conſider it is an oppoſite Extreme, and that f o is the middle part.

Sine f o + *Radius is = to Sine* ♈ + *Sine* ♈ o.



Sine f o the Suns Declination 13 *deg.* 15 *min.*	9,36021
Sine f ♈ o the com. of the Poles Elev. 40 *d.* co. ar.	9,19193
Sine ♈ o the Suns Amplitude of Riſing or Setting 20 *deg.* 53 *min.* 24 *ſec.*	9,55214

Uſe this way to find the Suns true Amplitude of Riſing, upon occaſion of finding the Variation of the Compaſs.

The Suns place of Riſing from the Eaſt towards the North, namely, Eaſt 20 *deg.* 53 *min.* 24 *ſec.* Northerly; O ♈ is the Complement of O E, the Suns Azimuth of Riſing from the North: ſo that if you ſubtract it from 90 *deg.* ♈ E the remainder is 69 *deg.* 6 *min.* 36 *ſec.* O E; but if you have a deſire to find the Suns Azimuth by the things you have given, here it is in the Triangle F E O, and is done as in this following Queſtion.

Latitude 50 deg. *Declination* 13 deg. 15 min. *I demand the Suns Azimuth of Riſing or Setting.*

LEt F O f P be an Arch of the Meridian, cutting the Sun at his Riſing (which is at O) f O is the Suns Declination 23 *deg.* 15 *min.* which ſubtracted from f F 90 *deg.* the remainder is O F 76 *deg.* 45 *min.* the Suns diſtance from the North Pole, and F E is the Poles Elevation 50 *deg.* 0 *min.* and thus you have two ſides given in the right angled Triangle O E F, to find the third ſide O F; its an oppoſite Extreme, and F O is the middle part: The general Axiom produceth this:

Sine com. F O + *Radius is* = *to Sine com.* F E + *Sine com.* O E.

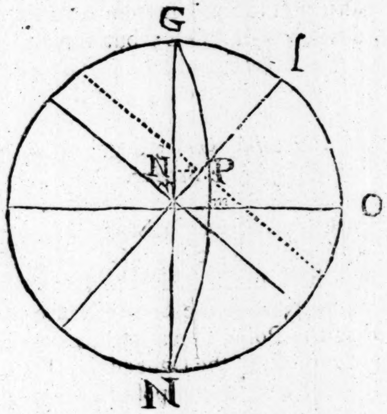
Sine com. O F 76 *deg.* 45 *min.*		9,360215
Sine com. F E 50 *deg.* 0 *min.*	comp. arith.	0,191932
Sine com. O E 69 *deg.* 6 *min.* 36 *ſec.*		9,552147

Thus I find the Sun riſeth to the Eaſtwards of the North 69 *deg.* 6 *min.* 36 *ſec.* which is E b N 9 *deg.* 38 *min.* 24 *ſec.* Northerly; the other Queſtion ſhews the ſame, when you find the Suns Amplitude.

Latitude 50 deg. *Declination* 13 deg. 15 min. *Northerly, I demand the Suns height at ſix of the Clock.*

LEt G P m N be an Azimuth paſſing through the hour of 6: Now in the Triangle ♈ m P, right angled at m, you have given P ♈ the Suns Declination 13 *deg.* 15 *min.* and the Angle at ♈, namely P ♈ m = to the Arch f O (for f O is the meaſure of it) it is the Poles Elevation 50 *deg.* 0 *min.* to find P m the Suns height at ſix of the Clock: I conſider it is an oppoſite Extreme, and the required thing P m is the middle part.

Sine P m -|- *Radius is* = *to Sine* P ♈ -|- *Sine* P ♈ m.



Sine P ♈ the Suns Declination 13 *deg.* 15 *min.*	9,360215
Sine P ♈ m the Poles Elevation 50 *deg.* 0 *min.*	9,884254
Sine P m the Suns height at ſix of the Clock 10 *deg.* 6 *min.* 51 *ſec.*	9,244469

The ſame things given, to find the Suns Azimuth at ſix of the Clock.

THe Suns Azimuth at 6 of the Clock is m ♈, and the reaſon is, for that P u in the Heavens (being parallel to the Horizon) is as many degrees in that Circle, as ♈ m is in the Horizon; for ♈ is under n, and m under P.

So that this Queſtion will fall in the ſame Triangle as the other did, and we will uſe the ſame things to find it.

The Angle P ♈ m is 50 *deg.* 0 *min.* the Poles Elevation.

P ♈ is the Suns Declination 13 *d.* 15 *m.* and ♈ m is required.

I conſider that this is an adjacent Extreme, and that P ♈ m is the middle part; The general Axiom produceth.

Sine com. P ♈ m -|- *Radius, is* = *to Tang.* ♈ m -|- *Tang. com.* P

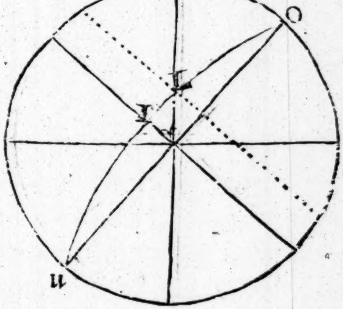
Ta

Tan. com. P ♈ the Suns Decl. 13 *d.* 15 *m.* com. arith.	9,371933
Sine com. P ♈ m the Poles Elevation 50 *d.* 0 *m.*	9,808067
Tang. ♈ m the Suns Azimuth 8 *deg.* 36 *min* 24 *ſec.*	9,180000

Latitude 50 deg. 0 min. *Declination* 13 deg. 15 min. *to find the Suns height being due Eaſt or Weſt.*

Let O L I u be an Arch of the Meridian, cutting the Sun in the Eaſt and Weſt Azimuth, and it helps to make the right angled Triangle L I ♈, in which lieth our buſineſs: For L ♈ is the Suns height being due Eaſt; and to find it we have I L the Suns Declination 13 *deg.* 15 *min.* and L ♈ I the Angle of the Latitude, beſides the right Angle; I conſider it it is an oppoſite Extream and I L is the middle part, there will be this inference produced from the general Axiom.

Sine I L + *Radius, is* = *to Sine* I ♈ L + *Sine* L ♈.



Sine I ♈ L the Latitude 50 *deg.* comp. arith.	0,1157459
Sine I L the Suns Declination 13 *deg.* 15 *min.*	9,3602154
Sine L ♈ Suns height being due Eaſt 17 *d* 24′ 34″	9,4759613

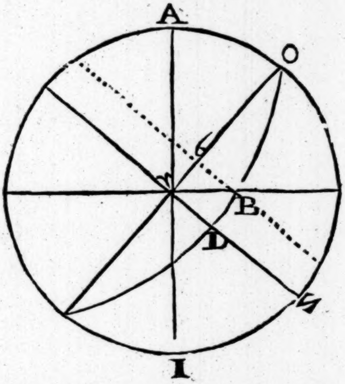
The ſame height that the Sun is being due Eaſt in the morning, the ſame height he is when he is due Weſt in the afternoon.

The Latitude being 50 deg. 0 min. *Declination* 13 deg. 15 min. *I deſire to know the Difference of Aſcenſion.*

I Have ſhewed what the Difference of Aſcenſion means in this Book before; and if you look in the Queſtion to find the Amplitude of the Suns riſing before, there is the ſame Scheme that this is, but for your better uuderſtanding I have here ſet it.

In the Triangle B D ♈ right angled at D, you have given D B the Suns Declination 13 *deg.* 15 *min.* the Angle at ♈ which is the Complement of the Arch I Z to 90 *deg.* or equal to O A the Complement of the Latitude 40 *deg.* 0 *min.* to find D ♈, which is as many degrees and minutes as B 6 is: It is an adjacent Extreme and ♈ D is the middle part: The concluſion from the general Axiom is

Sine Y D + *Radius, is* = *to Tan.* D B + *Tan. com.* D Y B.



Tangent D B Suns Declination 13 *deg.* 15 *min.*	9,371933
Tan. com. D ♈ B com. Poles Elevat. 40 *d.* 0 *m.*	10,076186
Sine ♈ D the Difference of Aſcenſion 16 *d.* 17′ 40″	9,448119

Which converted into time is 1 hour 5′ $\frac{2}{15}$ and $\frac{2}{3}$ of $\frac{1}{15}$ of a minute.

The

The ſame things given, to find the time of Sun Riſing.

FOr the doing of this, firſt find the Difference of Aſcenſion (as hath been ſhewed in the laſt Queſtion) and convert it into time; which done, ſubtract it from 6 hours, and you have your deſire (in this caſe where the Declination and Latitude is both one way) but in any caſe take this in general, that if the Difference of Aſcenſion be before 6 of the Clock, ſubtract it; if after 6, add it to 6 hours, and you have the time of Sun Riſing.

This ſtands to good reaſon, foraſmuch as the Difference of Aſcenſion is the portion of time that the Sun riſeth before or after 6 of the Clock.

In this Example you ſee the Difference of Aſcenſion is before 6 of the Clock 1 hour $5' \frac{3}{15}$ (we will omit the part of a part of a minute) I would know the time of the Suns Riſing.

Example.

Subtract the Difference of Aſcenſion	1 *h.*	5 *m.* $\frac{3}{15}$
From 6 hours	5	60
The remainder is the time of Sun Riſing	4	54 $\frac{12}{15}$ *or* $\frac{4}{5}$

Thus I conclude the Sun riſeth at 4 a Clock 54 *min.* $\frac{4}{5}$.

If you have a deſire to find the time of Sun ſetting, ſubtract the time of Sun riſing from 12 hours, and you have it; for as many hours and minutes as the Sun riſeth before 12, ſo many hours and minutes he ſets after 12.

Example.

Here the Sun riſeth at 4 of the Clock, 54 *m.* $\frac{4}{5}$ which we expreſs thus	4 *h.*	54 *m.* $\frac{4}{5}$
This ſubtracted from	11	60
Leaves the time of Sun ſetting	7	05 $\frac{1}{5}$

Which is 5 *min.* $\frac{1}{5}$ paſt 7 of the Clock in the afternoon.

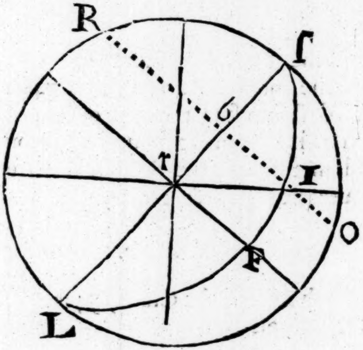
This doubled is the length of the whole day, which is 14 hours 10 *min* $\frac{2}{5}$.

This ſubtracted from 24 hours, is the length of the night, 9 hours 49 *min.* $\frac{8}{5}$.

To find the length of the longeſt Day in that Latitude before propoſed.

WHen the days are at the longeſt in any North Latitude, the Sun is in the Tropick of *Cancer*; in a Southern Latitude, in the Tropick of *Capricorn*: This is a Northern Latitude, therefore make the Tropick of *Cancer* the Parallel of the Suns Declination as here, O R is the Parallel of the Suns Declination, then muſt I 6 be the Difference of Aſcenſion, which is = to F ♈. In the right Angled Triangle I F ♈ right angled at F, you have I ♈ F the Complement of the Latitude 40 *deg.* given, and I F the Suns Declination 23 *deg.* 30 *min.* to find F ♈; find it as you was ſhewed to find the Difference of Aſcenſion before, convert it into time, and find the length of the day (as was ſhewed before) This note, that Sine ſ I F L is an Arch of the Meridian, cutting the Horizon in that place of it where the Sun riſeth.

Sine ♈ F + *Radius is* = *to Tang.* I F + *Tang. comp.* I ♈ F.



Tang. I F Suns Declination	23 *deg.* 30 *min.*	9,638301
Tang. com. I ♈ F Poles Elevation	40 *deg.* 0 *min.*	10,076186
Sine F ♈ Difference of Aſcenſion	31 *d.* 12 *m.* 39 *ſec.*	9,714487

But you may aſk all this while how this Fraction is found, it is thus found: Admit I would find the ſine of the Arch anſwering to 9714487, I look in the Sines, and find the neareſt leſs than it to be 9,714352

I take the next greater than it and find it to be 9,714560

I ſubtract the leſſer from the greater, the remainder is 208
Then from the figures that came forth 9,714487

I ſubtract the neareſt in the Tables leſs 9,714352

And the Remainder is 135

Then ſay,

As the Difference between the neareſt leſs and the neareſt greater 280 *comp. arith.* 7,681936
Is to the Difference between the ſame and that leſs 135 2,130333
So is 60 min. 1,778151

To 39 ſec. 1,590420

The like is to be underſtood of any Fraction elſe; if you have occaſion for the artificial Sine or Tangent of an Arch that hath a Fraction to it: Say,

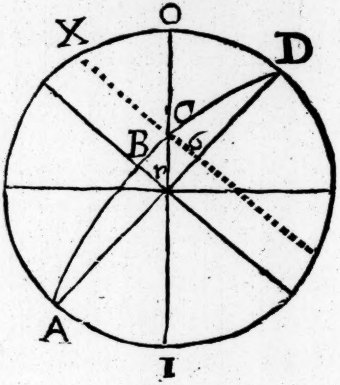
As 60 *ſeconds*
Is to the ſeconds in the Fraction, which is here 39
So is the Difference between the neareſt leſſer and the neareſt greater 208
—
To the Fraction 135
And this added to the leſſer, makes the artificial Sine of the Arch required 9,714352
9,714487
The like is to be underſtood of a Tangent.

To find the hour of the Suns being due Eaſt or Weſt.

Latitude 50 deg. 0 min. *Declination* 13 deg. 15 min. *Northerly*, *I demand the time of the Suns being due Eaſt or Weſt.*

IN the following Scheme I O is the Eaſt and Weſt Azimuth, R X is the Parallel of the Suns Declination, and cuts that Azimuth in C; from whence I conclude, that when the Sun is at C, ſhe is over the Eaſt point of the Horizon; D C B A is an Arch of the Meridian, cutting the Sun in C: So that in the

Tri-



Triangle C B r, you have given B C the Suns Declination, C r B the Angle of the Latitude 50 *deg.* 0 *m.* to find B r, which is as many degrees and minutes in a great Circle, as C 6 is in a leſſer; find it and convert it into time, and in this caſe add it to 6 hours, and it gives the hour of the Suns being due Eaſt.

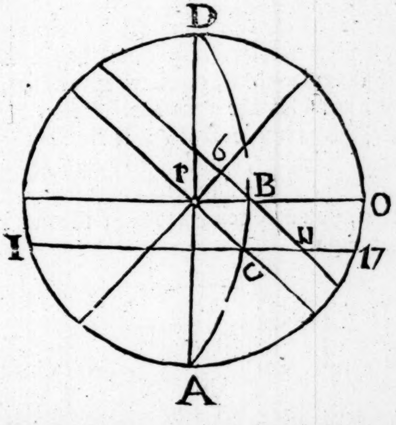
And for the time of the Suns being due Weſt, you are to ſubtract it from 6 hours, (in this caſe) and the remainder is your deſire: The reaſon is, becauſe as many hours as the Sun is due Eaſt after 6 of the Clock in the morning, ſo long time is he due Weſt before 6 of the Clock in the Afternoon. I have left the working of this to your own practice, only I have ſet down the Reſolution of it:

The Sun is due Eaſt 45 *min.* $\frac{9}{15}$ paſt 6 of the Clock.
The Sun is due Weſt 45 *min.* $\frac{9}{15}$ before 6 of the Clock.
Which is at 5 of the Clock 14 *min.* $\frac{6}{15}$.

Note, That if the Suns Declination be Southerly, then will he be Eaſt before 6; ſo that whereas here you add, there you ſubtract from 6 hours, to find the hour of the Suns being due Eaſt, or add to 6 hours for the time of its being due Weſt; but your own Reaſon (if you look well on the Scheme) will guide you to know this; and alſo to know that, it is uſeleſs in ſuch caſes, for then he is not above the Horizon.

Latitude 50 deg. 0 min. *Declination* 13 deg. 15 min. *I demand the Continuance of Twilight.*

AS I have noted before, the Sun is accounted 17 *deg.* under the Horizon when the day breaks; therefore in the following Scheme let 17 I, be an Arch parallel to the Horizon, 17 *deg.* under it: Let D B C A be an Azimuth cutting the Æquinoctial, and the line of 17 *deg.* in the place of their interſection, which is at C: then in the Triangle r B C (right angled at B) you have given B C 17 *deg.* the Angle B r C the Complement of the Poles Elevation 40 *deg.* to find C r the continuance of Twilight (for C r and B u are equal.) I leave it to your own Practice: I find the continuance of Twilight to be 27 *deg.* 4 *min.* which converted into time is 1 *h.* 48 *min.* $\frac{4}{13}$ neareſt.



So I conclude that between the Day breaking and Sun riſing, it is 1 *h.* 48 *min.* $\frac{4}{15}$, which is u B: Now if you add this to the Difference of Aſcenſion (before found) B 6, which was 1 *h.* 5 *min.* $\frac{3}{15}$ of a minute (I omit the ſmaller Fraction) you have the time between break of day, and 6 of the Clock, which may be termed u B 6 2 *h.* 53 *min.* $\frac{7}{15}$.

And becauſe the day breaks ſo much before 6 of the Clock, if you ſubtract it from 6 hours, you have the hour and minute of day breaking, which is at 3 of the Clock 6 *min.* $\frac{8}{15}$.

Add it to 6 of the Clock, and you have the time of Twilight ending, which is at 8 *h.* 53 *min.* $\frac{2}{15}$.

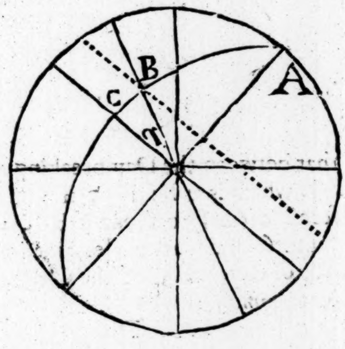
To find the Suns Place and Right Aſcenſion, provided, the Latitude and Declination be given.

Latitude 50 deg. 0 min. *Declination* 13 deg. 15 min, *I demand the Suns Place in the Eclipticks and right Aſcenſion.*

Right Aſcenſion is an Arch of the Æquinoctial between a Meridian, cutting the Æquinoctial and the point of *Aries* or *Libra*; the Meridian muſt alſo cut the Sun or Star in the Ecliptick as here in this Scheme: A B C is an Arch of the Meridian, cutting the Sun at B in the Ecliptick, and the Æquinoctial in C; then C ♈ is the Suns right Aſcenſion.

The Suns Place (as I ſhewed formerly) is the Suns diſtance in the Ecliptick, from the neareſt Æquinoctial point here B Y.

To find the Suns place ♈ B, you have given the Angle B ♈ C 23 *deg.* 30 *min.* and C B the Suns Declination 13 *deg.* 15 *min.* in the right angled Triangle B C ♈; it is an oppoſite Extreme, and C B is the middle part, I find it to be 35 *deg.* 5 *min.* if you propoſe the month and the day of the month that the Sun hath this Declination, you may tell what Sign the Sun is in, and what degree of that Sign.



As ſuppoſe the Sun hath this Declination here given upon the 14th. of *April*, I conſider what Sign belongeth to that Month, and I conclude it is ♉, then ſay I, as much as the Sun is diſtant from the next Æquinoctial point above 30 *deg.* (which is the Sine of ♈) ſo much he is entered into ♉, which is 5 *deg.* 5 *min.* I omit the Fraction.

For the Suns Right Aſcenſion.

You have the ſame things given in the ſame Triangle, to find the Suns right Aſcenſion C ♈; but this is an adjacent Extreme, and the required thing is the middle part.

I find it to be 32 *deg.* 47 *min.* ſome part of a minute more, (but I omit the Fraction.)

This muſt be converted into time, and then is your demand fully anſwered, it is 2 *h.* 11 *min* $\frac{2}{15}$.

Theſe be things neceſſary and very uſeful in Navigation for ſeveral occaſions, and that hath made me inſiſt upon them: If you are unacquainted with this way of working, my Father hath inſiſted upon it largely, and in his works, commonly called *The Doctrine of Triangles*; you may be ſatisfied both in the Doctrine of right lined Triangles, and Spherical. This I judge ſufficient for the two kinds of Sailing.

I would have handled ſomething in oblique Spherical Triangles, and ſo have proceeded to that incomparable way of Sailing by the Arch of a Great Circle; but the goodneſs of it is not known becauſe it is not practiſed: If you love that way of Sailing, (Reader) I commend thee to my Fathers *Doctrine of Triangles* in large, where it is largely treated of.

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